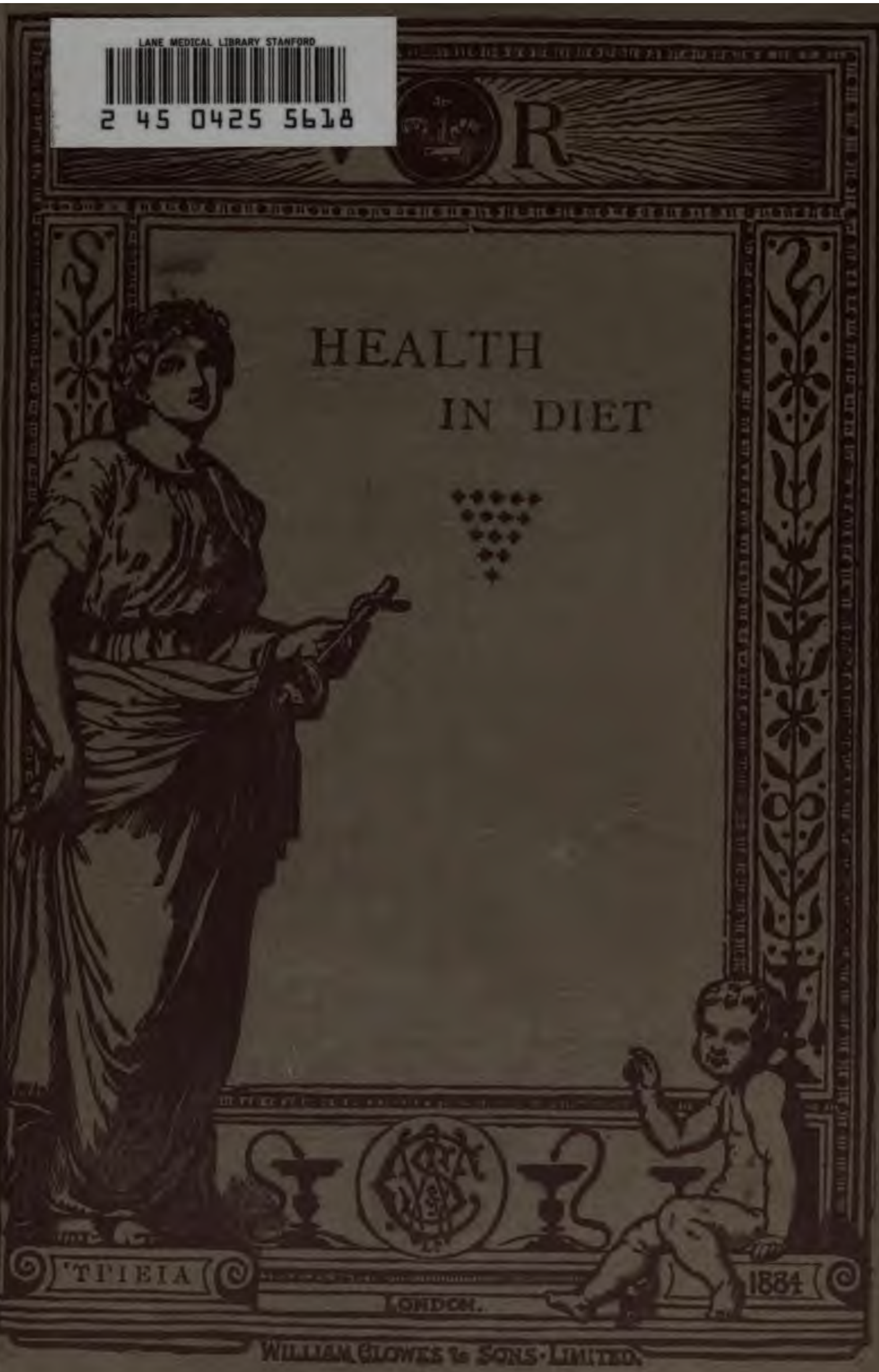
HEALTH IN DIET



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VOLUME VI.

HEALTH IN DIET.

LECTURES.

DIGESTIVE FERMENTS AND CHEMICAL PROCESSES OF DIGESTION.
THE REARING OF HAND-FED INFANTS.
PRACTICAL DIETETICS. THE CHEMISTRY OF BREAD-MAKING.
THE SCIENCE OF COOKERY.
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LECTURES.

THE

DIGESTIVE FERMENTS

AND THE

CHEMICAL PROCESSES OF DIGESTION.

BY

PROFESSOR ARTHUR GAMGEE, M.D., F.R.S.

LECTURES ON THE DIGESTIVE FERMENTS AND THE CHEMICAL PROCESSES OF DIGESTION.

By Professor ARTHUR GAMGEE, M.D., F.R.S.

JULY 1ST.

Professor HUXLEY, F.R.S., in the Chair.

The CHAIRMAN said the lecture about to be given was upon one of the most important topics, by a gentleman of high reputation as a physiologist, competent to give the best information in the most accessible shape, and in the shortest possible time. He need not dilate on the importance of digestion to every one, because probably there were very few who had not had considerable practical experimental evidence upon that point. Without going so far as to say, as a well-known cynic once did, that the two things desired in this life for happiness were to have a good digestion and no conscience, there was no question whatever of the great desirability of having a good digestion.

LECTURE I.

The Saliva and the Gastric Juice, and their Action on Food.

IN the lecture I am about to deliver before you I desire, in as elementary a manner as possible, to direct your attention to the earlier of the chemical processes of digestion, reserving for a second lecture certain other parts of the subject.

In thanking you, Mr. Chairman, for the honour you have done me in presiding on this occasion, permit me to say that your presence makes me wish that I could allow myself to enter on some of the higher developments of the subject: but at the same time it reminds me that you have conspicuously shown that it is one of the functions of the scientific man to take his share in popularising scientific knowledge.

In the short time at my disposal I wish to direct the attention of my audience to the chemical, as distinguished from the mechanical processes of digestion, and particularly to speak of those remarkable bodies, the so-called "*unformed ferments*" of the alimentary canal, and to point out in how many respects they differ from the other class of *organised ferments.* Want of time prevents my speaking, in however elementary a manner, of the food of animals, but I trust that at the present time every one looks upon food as matter which has to be taken, not only to make up for the loss of matter which is continually going on in the case of the animal body, but that which has to supply the animal with the *Energy* which it requires to perform all those numerous acts which together constitute life.

Let us take man as a type of the animal; the food of the animal body comprises solid alimentary substances and liquid alimentary substances; the latter consist almost entirely of water, and the former also contain no small quantity of water; indeed as a rule very much more water than solid matter. These solid alimentary substances may be divided into organic, and inorganic or mineral substances. It is the organic alimentary substances which may be looked upon as the fuel of the animal body, as furnishing it not only with the matter which is needed to make up the loss which the tissues and organs of the body are always undergoing, but the matter which supplies the energy required by the animal body. The organic alimentary constituents are built up for the animal by the vegetable. Even in the case where one animal feeds upon another the organic matter obtained from the animal is primarily built up by the vegetable organism. The organic

constituents of the body may be conveniently subdivided into certain groups. We have, in the first place, the group of proteids, or albuminous substances; secondly, the group of carbo-hydrates, which includes the starches and sugars; and, thirdly, the group of fatty matters, or fats. Any diet, in order to support the life of man, and I take man as the type of an animal, must contain, in addition to water and other mineral matters, the proper proportion of proteids, carbo-hydrates, and fats.

The process of digestion is the process by which the solid constituents of food, and to a certain extent, also the constituents capable of being dissolved by water, are by chemical and mechanical means so changed as to be capable of being absorbed into and forming part and parcel of the animal body. In considering the chemical processes of digestion, we shall have to inquire how these various organic food constituents are acted upon in different parts of the alimentary canal. When the solid food is introduced into the mouth it is in the first place, as you are aware, subjected to the mechanical process of Mastication, a process in which the teeth take the chief part and by which the food is broken down into small particles. This mechanical process is in most cases the almost necessary precursor to the chemical processes, which take place at the same time, and which have to follow. We are aware how much the process of solution of soluble bodies is hastened by the mechanical subdivision of the substances to be dissolved, and how very much the action of chemical agents is influenced by their being able to act upon a body in a state of minute subdivision; we are not surprised therefore that the substance of our food has, in the first instance, as a preliminary to the chemical process of digestion, to be subjected to the mechanical process of mastication. With this mechanical process, which I have treated at some length in the Handbook of Digestion, which will in a short time be published in connection with this Exhibition, I have nothing to do to-day, except to say that it could not go on but for the presence in the mouth of a liquid, to which

we give the name of Saliva, the first of the digestive juices. This liquid is the product of the living activity of certain glands which open by ducts into the cavity of the mouth, to which we give the name of the Salivary Glands. The largest of these glands are known as the Parotid Glands; they are situated behind the jaw, in front of the ear, and have a tube or duct passing from them opening into the cavity of the mouth. Next come the Submaxillary Glands, which are beneath the lower jaw, and a third pair of smaller glands, Sublingual Glands, which are found beneath the mucous membrane of the floor of the mouth, and which open by a number of small ducts. These three pairs of glands are the chief secretors of the liquid which we call saliva. The saliva which moistens our mouth has several functions. In the first place it is essential for proper articulation. Were the mouth perfectly dry, the complex movements of the tongue against the inner side of the mouth would be impossible; then again, the saliva helps mastication by moistening the food. It aids the process of breaking down the food; by its viscosity it also tends to knit together the broken down particles of the food, and to mould them ultimately into a so-called bolus or mass. In certain animals, however, and in man particularly, the saliva is a liquid which possesses distinct chemical properties. It is the first of the digestive juices proper. Let me point to a table of the digestive juices and their ferments, and you will find that saliva stands at the head of the first column. In the second column there is a ferment contained in the saliva, to which the name of salivary diastase is given. This has an action on one of the groups of food constituents which I have brought before you,—on the Starches, which belong to the group of Carbohydrates. The saliva in man, in the pig, and in a few animals exerts a chemical action, but in the majority of animals it does not exert any chemical action whatever. From this we gather that the functions of the saliva are in the first instance physical and mechanical, and that its chemical functions are to a certain extent subordinate; yet we must

not lose sight of them. The saliva is a liquid containing a large quantity of water. From the analyses of the saliva of man by Carl Schmidt, it appears that out of 1000 parts it contains 989 of water, and a small quantity of solid matter. Of that solid matter much is accidentally present, and is held in suspension, as are, for instance, epithelial cells, which have been rubbed off the surface of the mucous membrane of the mouth; of the really soluble matters there are but small quantities in the saliva, only 3½ parts in 1000.

What is the nature of the ferment which is present in the saliva, the so-called *Salivary Diastase*, though it is also known by other terms, as for example by the term of *Diastatic Ferment of the saliva*, or sometimes by the term *Ptyalin?* This salivary diastase is the first illustration which I have to bring before you of a so-called *unformed ferment*—of the typical kind of ferment found in the alimentary canal. The bodies which we call ferments, and which include both *organised* or so-called *formed* ferments and *unformed* ferments, are bodies which, looking at them now merely by their chemical effects, possess a power of bringing about changes of very great magnitude in bodies existing in the medium around them: changes incommensurably large when contrasted with the mass of the body which induces them. Take the case of the most widely known of these ferments, of the ferment which brings about the *alcoholic fermentation* in sugar. A few yeast cells fall into a saccharine liquid, and in the course of a certain time very remarkable changes occur. The temperature of the liquid increases, the liquid becomes turbid, bubbles of gas are given off, the smell of alcohol gradually becomes observable, and long before these more obvious phenomena, the microscopist has noticed the abundant development of the minute organism which is the cause of the whole of these changes. This ferment, Yeast, which brings about these remarkable changes in sugar, is a minute vegetable organism, and the changes which it brings about in the saccharine liquid are the results of its nutritive acts. If

by the action of heat, or of any poison, you kill the minute vegetable organism, it is quite impossible to make it bring about a change in the sugar. You could not, I may add, from the yeast-plant extract by means of any solvent or chemical agent whatever, anything which, added to sugar, would bring about the alcoholic fermentation, although one might from the yeast-plant extract an unformed ferment; for the yeast-plant does, in development, give rise to one of the unformed ferments (an "*inverting*" ferment) to which I am about to direct your attention.

A formed ferment, then, is a ferment which is absolutely connected with the life of an organism, and whose ferment action goes on only so long as a particular organism lives. What about the unformed ferments? Are they ordinary proximate principles which have nothing to do with life? Not so. The unformed ferments, which possess so much interest to us in connection with digestion, are invariably the products of the activity of living cells, but once formed, the cells which have given rise to them may die, and the ferment does not necessarily cease to exist. They are not absolutely linked with the life of the cell, and they may be extracted from the cell by the action of various solvents. We may, for example, by treating the tissues of a gland which contains a formed ferment,—a salivary gland (for example), with a solvent of its ferment, such as glycerin, obtain a glycerin solution which shall possess all the activity of the original gland cell, and this is a result which could not be obtained in the case of the formed ferments to which I first directed your attention.

There are a great many differences between formed and unformed ferments, but I shall only direct your attention to the most important. The most important, which I have not yet spoken of, is this: the formed ferment, as it exerts its ferment action, seems of necessity to multiply. As the yeast-plant goes on feeding upon sugar, and producing carbonic acid and alcohol, it multiplies. On the other hand, the unformed ferments, as instanced by the

ferments of the alimentary canal, in exerting their action, do not multiply. They possess, it is true, an extraordinary power; present in minute quantities, they may bring about changes of very great magnitude, but yet we find that the ferment does not increase as it goes on acting. In fact, the mass of evidence which we have, seems to show that in exerting their activity, even under most favourable circumstances, these ferments do gradually, but slowly and certainly, undergo deterioration and become destroyed. There are other differences, one of which is that pointed out by Paul Bert, as to the effect of compressed air or compressed oxygen upon formed and unformed ferments. He showed that whilst the organised ferments are destroyed in their activity, and annihilated, by exposure to the action of oxygen at a high pressure, the unorganised ferments undergo no such change. Let us now examine pretty closely the action of this Salivary Diastase or Diastatic Ferment. A great part of our food contains starch, generally boiled or acted upon in some way by heat—as, for example, in the case of the bread which we eat, which has been baked—but under certain circumstances unboiled. The saliva, in virtue of this ferment, possesses the power of dissolving and digesting (and we shall see in what the process of digestion consists) starch which has been subjected to the action of heat—cooked starch, we may call it. I have not time to touch upon the almost necessary details which I ought to enter upon with regard to the microscopic constitution of starch; but I may say that solid starch is obtained from vegetable bodies, and is found in the form of granules of a very complex constitution, formed in the interior of vegetable cells. It is simply a compound of the elements carbon, hydrogen, and oxygen. Its chemical formula is not yet perfectly known to us. The chemist tells us that starch is a compound having the composition, $C_{12}\,H_{20}\,O_{10}$, or a multiple of that. There are many facts which tell chemists that its constitution is not so simple as that, and that it should be represented thus: $(C_{12}\,H_{20}\,O_{10})_n$,

the value of *n* not being perfectly known. Some believe that the formula of starch, after it has been acted upon by water, is best represented by the formula $(C_{12}\ H_{20}\ O_{10})_{10}$. You all know what the action of water on starch is. If I take solid starch and mix it up with water, I obtain a milky-like liquid; and if I pour, as is usually done in the laundry, boiling-water on this milky mixture, I obtain a gelatinous solid; if I add more boiling-water, I obtain a more and more diffluent starch-paste, but it is doubtful if I ever obtain, by simply mixing with boiling-water, a true solution. Now when saliva acts upon starch-paste, it exerts an action which will be evident to you all. The first action of the salivary ferment is to render the gelatinous starch perfectly liquid. I shall try this experiment, which would succeed very much better if I had taken the precaution of heating the starch-paste. You observe the difficulty with which I succeed in transferring some of this starch-paste from the bottle to this beaker; but on adding to it a solution which contains some ferment, such as is present in the salivary gland, there is almost immediately a remarkable difference in the fluidity of the mass. It does not at once become fluid, and the time which elapses is affected very much by temperature, but still the difference in fluidity is very remarkable indeed. There are, it is true, still some solid lumps, but the great part of the mixture has become perfectly liquid. If, instead of taking quite so coherent a starch mass as I have employed, I take some starch-paste which flows with difficulty, but which is still diffluent, the change produced by this ferment is almost instantaneous. The liquid was viscid, but it is now absolutely diffluent. This action of salivary ferment is only the first of a series of actions. The salivary ferments, like the other ferments of the alimentary canal, act most efficiently at the temperature of the mammalian body—at a temperature varying between 98° or 100° Fahr., or 101° Fahr. At this temperature the conversion of gelatinous into soluble starch is almost instantaneous; and if the quantity of ferment in the saliva be considerable, at

once there are certain chemical changes which I must direct your attention to. The starch, under the influence of the ferment, combines with the elements of water, and is converted into a series of bodies called *Dextrins*, whilst at the same time there is formed a variety of sugar, long supposed to be identical with grape-sugar, but now known to be identical with the sugar formed in the process of malting barley, to which we give the name of Maltose. Let me demonstrate these changes induced by salivary ferment. I have a weak solution which contains about 1 per cent. of starch. First of all, I shall show you that this solution possesses properties which allow us to detect starch very readily in it. If to a solution of starch we add a solution of iodine, there is at once produced a very beautiful blue coloration, depending on the formation of an iodide of starch. Now, if we act on starch for a very short time at the temperature of the body by means of the ferment of saliva, we find, on adding iodine to the starch paste, that no blue colour is produced. The starch has ceased to exist as starch; it has given place to bodies to which the name of Dextrins has been given, and to Maltose. Apparently under the influence of the diastatic ferment, the very complex molecule of starch breaks down. The belief at the present time is, as I have said, that soluble starch is an aggregate of ten times $C_{12}H_{20}O_{10}$. The first action of ferment is to cause a combination of a molecule of water with the complex molecule of starch, and to give rise to a body called Erythrodextrin α (which is the first of the series of Dextrins) as well as to maltose. This body, being further acted upon by more ferment, is broken down into simpler Erythrodextrin β and maltose. The starch molecule further undergoes the process of degradation, until we have produced, as the ultimate product of the action of diastases on starch, certain very simple so-called Achroodextrins and sugar. But what is the object of these changes? The essence of the digestive processes is this: they do not merely dissolve bodies which are insoluble, but make them *diffusible*. I have prepared

several experiments, which I must pass over for lack of time, but I may just point to them without going into detail. This morning I poured into a loop of the intestines of one of the lower animals a solution of starch, and plunged this bag with intestinal walls in water; shortly before the lecture I took some of the water surrounding the intestine, tested it with iodine, and found that no starch had been able to make its way from the inside of the intestine to the water outside of it—that is to say, I ascertained that starch is indiffusible; that it does not make its way, at any rate with any ease, through animal and vegetable membranes. But, at the same time in another similar loop of intestine, I placed a similar solution of starch, adding to it a certain quantity of ferment identical to that of the saliva, and, as in the first instance, placed the intestine in a jar of water. On testing the water a short time since, by means of a test which enables us to determine the presence of very small quantities of grape sugar or of maltose, I found that there was a considerable quantity of maltose in the liquid surrounding the intestine. By the action of the ferment of the saliva, we have starch not merely converted into dextrins and sugars, but into bodies, for such are dextrins and sugar, which possess the power of making their way through membranes, of passing through the walls of lymphatics and blood vessels, and thus making their way into the blood of the animal fed upon starch.

The changes which take place under the influence of diastatic ferments may be very readily shown, although I hesitate to dwell upon them just now. Almost as soon as you have added the diastatic ferment to starch, you find that the iodine reaction becomes modified, and that sugar is present. If the quantity of ferment added be sufficient, you have a body which merely gives you a yellow tint with iodine, or no tint at all.

The food having in the mouth been subjected to the process of mastication, and a certain portion of the starch having been converted into dextrins and sugar, is then sub-

jected to the process of Deglutition, with which I have nothing to do, a process which has for its object the conveying of the *bolus* or mass of food from the mouth into the stomach, which we look upon as a bag, as a saccular dilatation of the alimentary canal, adapted in a remarkable manner both for the performance of chemical and mechanical functions. I have several diagrams which illustrate crudely one or two of the salient points to which I wish to direct your attention with reference to the stomach. The arrangement of fibres indicated shows the different layers of muscular fibres which constitute one of the coats of the stomach, fibres which have for their function the bringing about of movements of great complexity within the chief organ of digestion. The food, having made its way from the Oesophagus into the stomach, is subjected to very complex mechanical movements, which are almost as essential as the chemical changes which have to take place in that organ. The mechanical arrangements of the stomach are in some animals so powerful and so obvious that, before attention was directed in a proper way to the chemical action going on, many believed that the action of digestion was purely physical,—that it depended merely on the movements of the stomach. Now this saccular stomach is lined, like all parts of the alimentary canal, by a so-called Mucous Membrane—a lining membrane, within which are embedded certain glands, which we call the *Gastric Glands*. In most animals these gastric glands belong to two chief types; indeed, in most animals we can subdivide the stomach into at least two regions according to the classes of glands which are found in its mucous membrane. These glands are in some cases very simple. At first they were described as having the appearance of test tubes, being mere involutions of the mucous membrane of the stomach, but careful examination has shown that the simplest of the gastric glands have in most animals a complex structure. In the stomach of the dog, which perhaps affords the most typical instance of a stomach in which you have two well defined regions,

you have at the *Pyloric End*, that is, the end which approaches the small intestine, certain glands in the mucous membrane which used to be spoken of by the older anatomists as *Mucous Glands;* at the upper end of these glands is a single tube, lined by so-called *cylindrical epithelium*, but this leads to secondary tubes, and these secondary tubes are lined by cells, no longer cylindrical, but which may be described as cells of cubical epithelium. These cells were formerly supposed to merely secrete viscid stringy mucous, but we now know them to co-operate, though in a subordinate degree, with the glands of the fundus in secreting one of the most important constituents of the juice to which I have to direct your attention, viz., *Pepsin.* Then at the other end, the so-called *Fundus* of the stomach, in most animals, and in all parts except the pyloric end, we have in the mucous membrane glands of more complex character. In the deeper portions of these glands we have two forms of cells; we have certain ovoid cells, which are situated for the most part peripherally, that is, near the margins of the tubes, and which we may term *Border Cells;* then we have between them and most internally certain cells which we call the *Central Cells.*

What is the object of this bag having a lining membrane possessing a large number of glands. These glands have for their function the secretion of the digestive juice called the Gastric Juice, which is the most important of all the digestive juices. When the stomach is at rest, that is to say, when it is empty, the lining membrane possesses a pale colour, and when blue litmus paper is drawn over its surface it is found that in many parts the reaction is neutral or alkaline. You may ask me how these facts have been discovered. They have been discovered, in great measure, in cases where, as the result of injury or disease, the interior of the human stomach was, as it were, laid bare to the gaze of the investigator. When food enters the stomach, however, the pale mucous membrane begins to flush, little droplets of a liquid having a very acid reaction are observed to exude from all parts of its surface. These little droplets,

at first seen here and there, become more and more numerous, and run together, and at last we have pools of the acid gastric juice accumulating in the stomach. It is this gastric juice, acting in conjunction with the mechanical movements of the stomach, and at the temperature of the body, which possesses the power of acting upon one of the chief groups of food constituents, though not upon the group to which I have as yet directed your attention. For a moment let us look at the composition of the gastric juice. On the wall, there is a table showing the analysis of the gastric juice of the dog made by Schmidt; in 1000 parts of fluid there are 973 of water. Of organic matters there are present about 17·13 parts, and you further see that the organic matters contain *Pepsin*, to which body I shall have to direct your attention very particularly. Upon what does the acidity of gastric juice depend. It depends upon *hydrochloric acid.* This fact has been surmised for a long time; it was found by some of the earlier chemists between 1820 or 1830 that when the gastric juice was subjected to distillation hydrochloric acid was obtained in the distillate, but it was pointed out that this afforded no sufficient proof that the gastric juice contained hydrochloric acid, because if the gastric juice contained such salts as common salt, and such an acid as lactic acid, by the reaction of the lactic acid on the common salt under the influence of heat, hydrochloric acid would be produced; further, it was doubted whether this strong mineral acid could be produced by the cells of the gastric glands. The matter was well-nigh settled many years ago by Carl Schmidt, who pointed out that the chlorine which exists in the gastric juice is greater in amount than could exist in combination with the whole of the mineral bases of the gastric juice, and his observations in that respect have been confirmed by a more recent investigator, Charles Richet, who has, however, advanced new ideas as to the nature of the acid of the gastric juice. There are several experiments which indicate in a remarkable way that the acid of the gastric juice is a mineral acid. Not only does it contain

more chlorine than would be present except as hydrochloric acid, but it is evident that the acid is a mineral acid because of the action exerted by it on certain colouring matters. I have here an exceedingly weak solution of hydrochloric acid, of about the same strength as the gastric juice, the normal acidity of the gastric juice being equal to about 0·2 per cent. of hydrochloric acid. I have also an alcoholic solution of a very complex organic dye, known in trade as oo-Tropaeoline. When this colouring matter is added to a very weak solution of a mineral acid you observe an exceedingly beautiful pink colour, whilst when the solution contains only a small quantity of an organic acid, like lactic or acetic acid, no such colour is produced. It can be shown that in the normal stomach, and generally even in cases of disease, the acid is one which reacts with this colouring matter as a mineral, but not like an organic, acid. We may, therefore, I think, at present dogmatically state, and I do not believe that our doctrine will be controverted successfully, that the acid of the gastric juice in a healthy stomach in the earlier stages of digestion is hydrochloric acid. It has, I may point out, been stated by Richet that probably hydrochloric acid does not exist in a free condition, but combined with Leucine.

Passing from the acid of the gastric juice to the chief ferment, what is Pepsin? Pepsin is the chief unorganised ferment of the gastric juice, and it is the ferment which possesses the power in the presence of free acid, especially of free hydrochloric acid, at the temperature of the body, of acting not upon starch, not upon fats, but upon the so-called proteid or albuminous constituents of food, that is, those constituents represented to us by the albumen of white of egg, by the casein of milk, and by the gluten of bread. The majority of the proteids which we take in our food—for instance, those contained in meat—exist in an insoluble condition. The meat is broken up by the action of mastication in our mouth, it passes into our stomach in an insoluble condition, and is there acted upon by this gastric juice; it is to a great extent brought into solution,

and the agents engaged are pepsin and hydrochloric acid. The hydrochloric acid is there because it is an essential condition that there should be a free acid in order that the pepsin should exert any influence.

I wish to show you the action of pepsin and hydrochloric acid in bringing about the solution of proteids, by an experiment which I trust may be obvious to you. In the first place, yesterday I obtained some fibrin. You know when the blood which has issued from the blood vessels of animals is stirred, there separates round the stirring implement, of whatever kind it may be, a stringy substance belonging to the class of proteids and to which we give the name of fibrin. We may wash this until it is quite free from colouring matter, then dry it and it presents the appearance of the solid contained in this bottle. Now this fibrin is a typical proteid with which we may make experiments on digestion. I placed some in dilute hydrochloric acid of the strength of that in the gastric juice; and the fibrin has swollen very much, but not dissolved. That is one of the facts to which I direct your attention in reference to digestion in the stomach. The proteids have a great tendency, particularly fibrin, to swell, when placed in dilute hydrochloric acid. There is no solution, none whatever. I placed some of the fibrin at the time I dried the portion I showed you, in an ammoniacal solution of carmine; this colouring matter was taken up by the fibrin, and we obtained a red solid, which has been partially but not completely dried. This morning I placed some of this stained fibrin in dilute hydrochloric acid, when it began to swell, and the two funnels before us are nearly filled with a jelly of swollen coloured fibrin. If I pour water upon this red jelly it will not dissolve; if I pour hydrochloric acid upon it, it will not dissolve, and we can tell that it does not dissolve because, if it dissolved, there would pass into solution not merely the fibrin but its colouring matter. Let us try this experiment. Over the contents of one of the funnels I pour dilute hydrochloric acid at the temperature of the body, and pour over the contents of the second funnel a mixture of dilute hydro-

chloric acid, and pepsin. Before doing so, let me say that this solution does not contain pepsin in a state of purity. We spoke of the diastatic ferment of the saliva as if we had separated it and analysed it, but we have not. We judge of its existence merely from numerous facts as to the influence which it exerts; and the same is true of pepsin. We speak of there being a ferment in the gastric juice called pepsin, not because we have ever obtained pepsin in a state of purity, but because there are a great many facts which show us that such a ferment must exist. Indeed, we could not account for all the facts of gastric digestion without the hypothesis of this ferment. More than that, by acting with solvents on the mucous membrane of a dead stomach, we obtain solutions containing this ferment—solutions of pepsin—which we may employ in experiments on digestion. The researches which have been made on this subject, like nearly all physiological researches, are proving of infinite value to suffering humanity. If there is any knowledge which very soon finds an application, it is physiological knowledge, and for that reason, if for no other, we ought to be slow in throwing hindrances in the way of physiological research. As the result of the researches of which I am giving you an account, solutions of pepsin have been made in different ways by acting by means of solvents upon the stomach, and they have come to be much used in medicine. At the present time, for example, in England, where I believe we have much the best of these preparations, there are at the disposal of the physician such admirable preparations as Bullock's Glycerine Extract of pepsin, a solution obtained by treating the mucous membrane of the stomach with acid and glycerine; we have an admirable solution made and sold under the name of Pepsine Essence, by Messrs. Savory and Moore, and likewise an excellent Liquor Pepticus, prepared and sold by Messrs. Mottershead; all these solutions, which are found in commerce, are the result of scientific work, and are very much used in medicine. I shall employ one of these solutions in this experiment. I take first of all some

warm dilute hydrochloric acid, and pour it over the contents of one funnel, then I add a solution of pepsin to the rest of the hydrochloric acid, and cause it to act on the fibrin in the other funnel, and I shall have in a short time considerable quantities of red liquid accumulating in the beaker placed below the second funnel showing that the fibrin is almost instantaneously being dissolved before us, and in large quantities. I may show you this experiment in another way. Two or three hours before the lecture I placed some masses of the stained fibrin in dilute hydrochloric acid. You will observe that the fibrin has swollen up, but that it remains undissolved; some traces have passed into solution, that being due to the fact that my stained fibrin had not been thoroughly washed. Here however is a tube in which I have placed an equal quantity of fibrin with hydrochloric acid and with pepsin, and you will observe that the whole solid mass has passed into solution, giving us a red liquid; the proteid matter of the fibrin has been dissolved under the influence of pepsin and acid. If I had taken pepsin alone, and added it to the swollen jelly, there would have been no solution, as when I took acid alone, there was no solution; but having taken pepsin and acid I obtain a solution of the fibrin.

Now, what are the substances which are produced under the influence of pepsin and hydrochloric acid? The bodies *ultimately* produced under the influence of these agents are termed *Peptones;* like the body from which they are derived, they belong to the group of proteids, represented by albumen, casein and fibrin. The peptones have these characteristics: they are exceedingly soluble bodies, much more soluble than the most soluble proteids and they are also more diffusible than the most diffusible proteids. When albuminous food, then, enters our stomach, under the influence of the gastric juice, aided by the mechanical movements of the stomach, the proteid constituents are brought into solution, and are converted, at any rate in great part, into soluble matters, which have the power of passing through animal membranes, and

thus make their way into the lymphatic channels and into the blood vessels.

Now, let me for a moment touch on this question, Is there any other ferment present to the stomach? and the answer is, Yes. Especially in the stomach of young animals there is present another ferment to which the name of *Curdling Ferment* or *Rennet Ferment* is given. In virtue of the presence of this ferment, the Casein, which exists in solution in milk, is curdled or coagulated. This ferment was long ago recognised by the great chemist Berzelius, as not identical with the ferment to which I have referred, namely, pepsin, for the conditions of its activity are different. If you take the gastric juice and neutralise it, it will no longer dissolve proteids; its pepsin no longer exerts its action, but it will yet continue to curdle milk. There are now a great number of reasons for saying that the curdling ferment is quite a special ferment, and it possesses a remarkable power on the casein of milk, not merely coagulating and precipitating it as it would be precipitated by mineral acid, but altering it in a material manner; the action of the rennet ferment is indeed to convert *Casein* into *Cheese*, cheese being perfectly different from the body we throw down from milk when we add an acid to it.

The CHAIRMAN proposed a vote of thanks to the lecturer, which was carried unanimously.

July 8, 1884.

LECTURE II.

Gastric Digestion further considered: Pancreatic Digestion.

In my first lecture, when speaking of the glands which are found in the cardiac portion or *fundus* of the stomach, I omitted to mention one or two very interesting points with regard to their cells and the function of these. You will remember my saying that when the stomach is at rest and empty, on food entering the stomach, there commences to be secreted from the tiny little glands, whose mouths open upon the surface of the mucous membrane, a juice called the *gastric juice*, of very acid reaction, the acidity depending upon hydrochloric acid, and you will remember my bringing before you some of the evidence upon which this opinion is based. You will remember that this juice, besides hydrochloric acid, contains one of the unformed ferments of the alimentary canal, to which we give the name of *Pepsin;* and that in virtue of pepsin on the one hand, and hydrochloric acid on the other, at the temperature of the body, aided by the mechanical action of the stomach, the most important of the operations of digestion is effected—that whereby the greater part of the albuminous or proteid constituents are brought into solution and converted into bodies called *Peptones.* I omitted, however, to mention in my last lecture that the hydrochloric acid of the gastric juice is unquestionably secreted in the glands of the *fundus* of the stomach, and in the

cells of those glands possessed of both central and border cells. These glands have come to be called "*oxyntic*," or acid-producing glands, and the acid-producing function is resident in the ovoid "*border*" *cells;* on the other hand, the powerful ferment Pepsin is produced both in the glands of the fundus and in the glands of the pylorus by other cells than the ovoid cells. Between these border cells are many others in the glands of the fundus, and these form pepsin. Again, the deeper parts of the glands of the pylorus contain cubical cells, which form some pepsin. It is impossible to give the grounds for making these assertions which rest on conclusive evidence derived from many different sources.

In the stomach the starchy constituents of the food undergo but very little change. Do they undergo any change whatever? It has been a question whether the saliva which has commenced to act upon the starchy constituents of the food in the mouth continues its action in the stomach, and the discussion on this question still goes on. There are some who say that the moment the food enters the stomach the saliva ceases to exert any action upon it, whilst there are others who maintain the opposite opinion. I shall dogmatically tell you what I think the truth of the matter. There can be no doubt that the diastatic ferment of the saliva can only convert starch into dextrins and sugar when the reaction is alkaline or neutral, or at most but faintly acid. When the saliva enters the stomach in full digestion, *i.e.*, when the gastric juice has been secreted in large quantities, and when the acidity of the juice is great, then it loses its power of acting on starch; but in the very first stages of digestion there can be little doubt that the digestion of starch goes on. For some little time, the saliva, mixed as it is with the crushed up food, continues its action upon the starchy constituents, so that, although there is no conversion of starch into dextrins and sugar at the expense of anything secreted by the stomach, there is a certain degree of conversion due to the continued action of the saliva, favoured by the warmth of the

stomach. In the main, however, the starchy constituents of food are not acted upon in the stomach. But what about the fats? The fat which we consume in our food is to a considerable extent contained within the interior of cells; the fatty tissue, the so-called *adipose tissue* which we eat, is found microscopically to consist of little vesicles or sacs, which contain fat liquid at the temperature of the body. A liquid fat itself is not acted upon by the gastric juice, but unquestionably the walls of the fat cells are dissolved by the juices of the stomach, so that indirectly the gastric juice tends to the digestion of fats. The fatty matter of our food under the influence of gastric digestion is in great part set free, so that when it is afterwards subjected to the action of the pancreatic juice, a true chemical action may be exerted upon it. It is thus the proteids or albuminous constituents which are acted upon chiefly in the stomach.

I want to tell you that these proteids are more important than any other constituents of our diet. A man may live without starch and without fat, although he cannot conveniently live either without fat or without starch. But an animal deprived of the proteids must die. We may say that the substratum of our body is proteid, that the framework of our body is composed of matters which in the main are proteid or albuminous in character, that is, akin to the white of egg, to the casein of milk, to the fibrin of blood, or to the matter which makes up the chief part of the fibres of flesh. Now our bodies are always wasting; do what we may, every part of the animal machine is continually wasting. Although we cut off all food from without, and abstain from all external work, still the losses of the body continue, and amongst these are losses always attributable to this proteid part of the organic framework of the body. We are continually losing from our bodies matters rich in nitrogen, and there is only one way in which the body can make up for that loss, and that is by taking into itself stores of nitrogen in the form of the proteid bodies which I am speaking of; for the only

source of the nitrogen which the animal body can avail itself of is found in proteids. These proteids, for the most part taken into the body in the insoluble form, are acted upon, as we have seen, by the gastric juice, in virtue of pepsin acting in an acid medium at the temperature of the body, aided by mechanical movements, and are converted into Peptones. A word with regard to these peptones, in addition to what I said in my first lecture. These peptones are very soluble proteid bodies, and more than that, they are proteid bodies which, like the dextrins and sugars, are diffusible; they can make their way out of the alimentary canal, which in one way may be looked upon as outside of the body, into lymph-spaces, and into the blood-vessels, and so come to enrich the body and supply it with that which it is continually losing.

After the food has sojourned in the stomach for some time, and has been acted upon by the gastric juice, it is broken down and reduced to a pappy condition; the watery parts of the food are absorbed by the blood-vessels of the stomach to a certain extent, and by other absorbent vessels, the lymphatics. The substances which have been formed by the action of the digestive juices—the dextrins, the sugars, the peptones—are in great measure absorbed from the stomach; but there yet remains a pulpy mass, which, when examined under the microscope, is found to be composed of half-digested and broken-down proteid substances and undigested vegetable matter. If the diet has been a mixed animal and vegetable diet, the residual undissolved mass consists of broken-down particles of meat, mixed with yet undigested starch, and indigestible cellulose, and with fat set free from adipose tissue. In the early stages of digestion, the pyloric orifice is closed against the passage out of any constituent of the food, which, by the complex movements of the stomach, is kept in continual motion. For a certain time, every particle of the food is given a chance of being acted upon by the solvent gastric juice. But as the food is broken down under the influence of the gastric juice,

and becomes more and more pulpy, the pyloric orifice begins to gape, and gradually the pulpified mass of so-called *Chyme* makes its way through the half-opened orifice into the upper portion of the small intestine, into the so-called *Duodenum*. When the pulpified chyme comes into the duodenum, it is acted upon by two fresh juices, which are poured into this portion of the small intestine from two important glands. One of these juices is called the *Bile*, and is the product of the secretive activity of the liver; the other juice is called the *Pancreatic Juice*, and it is the product of the gland called the *Pancreas*, which in the lower animals is popularly known by the name of the sweet-bread. This pancreas also has a duct or tube running from it, which opens into the intestine at the same point at which the bile-duct opens. The bile used to be looked upon as a very important juice at one time. I have not time to speak at any great length of this liquid, except to say that we now look upon the bile very much as we should upon a by-product, or refuse, of a great chemical factory. The great gland, the liver—the largest gland in the body—performs some most important functions in connexion with the nutrition of the body—it is the seat of some great chemical operations upon which I cannot enter just now; and in the course of these there are formed certain refuse matters which pass out of the liver dissolved in water, and these constitute the bile. The bile exerts no direct action upon food constituents; it contains in most animals no ferments whatever. It contains Colouring Matters, derived originally from the blood-colouring matter. It contains certain Salts of the *Bile Acids*, these bile acids being, as I have already said, by-products of the great chemical operations which take place in the liver; but there is no direct chemical action exerted by the bile on any of the organic food constituents. The bile is, however, an alkaline liquid, and it helps digestion a little in this way. Mixing with the chyme which has passed out of the stomach, and which has yet a very acid reaction, it helps to neutralise it, and, as we shall see, in this way it helps to bring about the conditions

so necessary for the action of that marvellous gland the *Pancreas.*

The Pancreas resembles very closely in appearance one of the salivary glands which I spoke to you about in my first lecture; in microscopical structure, also, the pancreas resembles the salivary glands, and it secretes a liquid possessed of an alkaline action, and at first sight presenting a resemblance to Saliva. Indeed, by the Germans, the pancreatic juice has been spoken of as abdominal saliva. Its action on the constituents of food is however infinitely more important than that of the saliva, and in the rest of this lecture I wish mainly to direct your attention to this juice, whose functions have only been properly appreciated during the last few years, and whose action upon the constituents of food we have not yet entirely unravelled. So far as we have unravelled them, we have obtained, however, information of the greatest possible value.

The pancreatic juice is a decidedly alkaline juice. You know that the gastric juice, which is the most important digestive juice, has a strong acid reaction, due to the presence of free hydrochloric acid, and I want you to note that the alkalinity of the pancreatic juice actually depends on the presence of sodium carbonate in that liquid. It is a remarkable thing that in the alimentary canal we should have poured out by the glands of one organ a fluid containing large quantities of a mineral acid, and in an adjacent organ a liquid containing considerable quantities of an alkaline salt; that in one case the mineral acid, and in the other the alkaline salt should be of the greatest possible utility, indeed almost essential, to the digestive processes which have to go on. Now, the pancreatic juice differs from the two juices which I have yet spoken of, to wit, the saliva and the gastric juice, in its power of acting on all three groups of organic food constituents. In all animals the pancreatic juice can digest starches and can convert them into dextrins and sugars. Our great herbivores upon whose tissues we feed, which have to rely so much under certain circumstances on the starch contained

in the vegetable food which they consume, have a saliva which exerts no action on starch, but they all have a pancreatic juice, which can with the greatest readiness convert starch into dextrins and sugar. I shall repeat the experiment I showed you last week. We have here a thin starch mucilage, a viscous liquid which does not pour like water, but if I add to this viscous liquid a solution which contains the active principles of the pancreas, the viscidity disappears almost instantly. You observe the liquid now flows like water, and if we had had time we could easily show that it already contains large quantities of sugar, the product of the action of one of the ferments of the pancreas; for this marvellous gland, the pancreas, secretes a juice containing *three* ferments.

The first ferment is a diastatic or amylolytic ferment, and it is contained in large amounts. The second ferment possesses an action upon fats. What action? In the first place it was found long ago that when you shake the pancreatic juice of an animal with fatty matter, with oil for example, you very readily emulsify the oil. Permit me to comment on this for one moment; if I take some olive oil and mix it with water and shake it up I produce for a moment a somewhat milky-looking liquid, but in a very little time the oil floats to the top, and you have the water remaining clear below. When you shake up olive oil with water you do not produce an *emulsion.* But if I take mucilage and shake it up with a little oil, I produce a milky liquid containing fat reduced to a minute state of division. Here, for example, is an emulsion which was made by mixing up almond oil with solution of gum acacia. It is a liquid which closely resembles milk. If we examine it under the microscope we find that it contains little globules of fat. Sooner or later, however, with ever so perfectly made an emulsion there will be a separation of fat in droplets which will float to the surface: but the separation will be slow and incomplete. I have said that it was discovered long ago that the pancreas secretes a juice which possesses in a high degree

the power of emulsifying fats. It was discovered at the same time that the tissues of the gland likewise possess the power of aiding the emulsionising of fats. This fact has been made use of for the purposes of medicine in certain preparations for which one of our pharmaceutical firms has acquired great renown. The so-called Pancreatic Emulsion of Messrs. Savory and Moore, which for many years has been used in medicine, is a preparation in which this power of the pancreas of bringing about the emulsionising of fats has been taken advantage of, so as to obtain fats in an extremely fine state of division, in which condition they appear to be most readily absorbed from the alimentary canal. We do not know exactly how it is that the pancreas, and the pancreatic juice lead to this emulsionising of fats, but we do know something of another action exerted by pancreatic juice on fats. We know that the pancreatic juice, and the gland which yields it, contains in addition to a diastatic ferment, a second ferment, which we may call a *fat-decomposing ferment*, and this fat-decomposing ferment, at the temperature of the body, readily decomposes fats to a certain extent. I have not time, and this would not be the place, to enter into a discussion the chemistry of the fats; those of you who are acquainted with organic chemistry know the so-called fats contained in adipose tissues of animals, as ethers of the triatomic alcohol, called glycerin. I am quite aware that that is perfectly unintelligible to the ladies, and perhaps to some of the gentlemen present, but let me add some simpler and more explicit statements. The fats are all, in the first place, composed of three elements, carbon, hydrogen, and oxygen. Further, all the true fats of the animal tissues may by a certain treatment be broken up into glycerin, and a fatty acid; for example, by the action of an alkali, like potash or soda on neutral fats, aided by heat, they can all be broken up into glycerin, and into compounds, of a fatty acid and an alkali; to the latter compound we always give the name of a Soap. Now, the chief fats contained

in the animal tissues are three, called Palmitin, Stearin, and Olein, or to be a little more accurate, tri-palmitin, tri-stearin, and tri-olein. Whenever fresh pancreatic juice or fresh tissue of pancreas, comes in contact with a neutral fat at the temperature of the body, these neutral fats are *to some extent* split up into the particular fatty acids and glycerin. I have here an emulsion which has been made by shaking up almond-oil and gum. I shall add to this emulsion some litmus, and from the blue colour which develops, we see that the reaction of the emulsion is alkaline. The emulsion is at the temperature of the mammalian body, that is 40° Cent. I now add to this preparation a preparation made from pancreas, the so-called Pancreatinine of Messrs. Savory and Moore. In shaking up the liquid we at once see that the blue colour has made way for a red colour—that is to say, a decomposition of the neutral fats into fatty acids and glycerin has occurred. This decomposition is brought about by the second ferment of the pancreas, and there is good reason to believe that the setting free of the small quantity of fatty acid plays an important part in the formation of emulsions. There can be no doubt at all that, but for the pancreatic juice which enters the small intestine, the fatty matter would not be emulsified, and would escape absorption by the absorbent vessels of the alimentary canal.

The third and most important ferment of the alimentary canal is a Proteolytic ferment, that is to say, one which exerts an action on the same constituents which are acted upon by the gastric juice. This proteolytic ferment of the pancreatic juice is called *Trypsin.* Though it exerts its action on the same constituents as those which are acted upon by the gastric juice, it is quite different from Pepsin, and the conditions for its activity are very different also. You may say to me, what is the need of there being another ferment to act upon the proteids? what need is there for a gland to pour a liquid into the small intestine which shall act on the very food constituents which already have had the chance of being acted upon in the stomach? The answer is this. However long the process

of digestion in the stomach, certain proteids always escape solution in the stomach, and have to be subjected to the further action of the ferment trypsin, so that if possible they shall be made available for the purpose of the economy. Trypsin, unlike pepsin, acts best in an alkaline medium, and that is the reason why the pancreatic juice is alkaline: its alkalinity being indeed equal to the alkalinity of a solution which contains about one per cent. of sodium carbonate. It used to be supposed at one time that the proteolytic ferment of the pancreatic juice acted only in alkaline solutions. That is false. Unquestionably, trypsin does not act efficiently in the presence of a strong acid; it does not act efficiently, for example, in the presence of the acid of the gastric juice, but it can, though feebly, exert its action in the presence of a mere trace of acid, or in a neutral solution. It only acts to the best advantage, however, when the liquid in which it is present is decidedly alkaline.

Now what are the products of the action of trypsin on the proteids? You remember that peptones are ultimately formed by the action of pepsin and hydrochloric acid. Now we have to consider what are the bodies which are formed by the action of trypsin and soda; are they peptones? The answer is, in the first place, that the bodies produced under the influence of the trypsin of the pancreatic juice are peptones, but certain of these peptones are further acted upon and broken up into bodies of simpler constitution than the peptones, to which the chemist gives the name of Leucine and Tyrosine.

Had I time, it would be, I think, interesting to enter in an elementary manner into the points of difference between the action of pepsin and hydrochloric acid and trypsin and soda, but I must pass over all these minute details, and speak of those which I know must possess a greater interest to you. This question is one which is of interest—is pancreatic digestion of great importance? Does the pancreatic juice during life possess the chance of exerting great influence, and so play an important part in the digestive process? Unquestionably it does.

I mentioned the other day that the studies which had been made upon pepsin, and at first with purely scientific objects, have proved of the greatest possible value, and I now have to point out to you the immense value of the studies, at first made for purely scientific objects, concerning the action of the pancreas, and especially the proteolytic action of the pancreas, exerted by means of its ferment trypsin. We have seen that of all the constituents of food the proteids are the most important. We may be deprived of starches and yet live: we may be deprived of sugar and yet live: we may go without fats: but unless we have proteids we must die.

There are conditions induced by disease in which proteids cannot be digested. There are, for instance, affections of the stomach in which the glands of the stomach no longer possess the power of secreting its digestive juice adequately, and then the unfortunate human being is in the position of undergoing a more or less slow starvation. Now I am not going to enter on any painful or unpleasant details: I am rather going to tell you how science has come to the aid of suffering humanity, and afforded us the means of relieving and of nourishing those who under these circumstances otherwise must starve. The ferments of the alimentary canal, as you have been able to gather from the remarks I have yet made, not only reside in their juices, but are to be extracted from the very tissues of the glands which form them. We may, for example, from the salivary glands of an animal which secretes active saliva, obtain a solution which possesses the power of acting on starch; similarly, we can, from the dead stomach of animals, which secrete gastric juice, obtain pepsin; and so medicinal preparations of pepsin are made principally from the stomachs of pigs. From the sweetbread or pancreas of dead animals we may similarly obtain preparations containing the ferments which, during life, pass into the pancreatic juice, and effect the remarkable changes in the alimentary canal to which I have drawn your attention. Scientific men pointed out these facts, and manufacturers,

readily followed in the wake, and have succeeded in preparing extracts of pancreas, or solutions of pancreas, with which we can artificially digest. We have only to take certain alimentary constituents, add to them pancreatic preparations, and place them at the temperature of the human body, and digestion will go on as it would in the alimentary canal, and we may obtain those products which are the results of the action of the digestive juices; these products, it is found, can be taken by human beings when all others would be rejected.

I shall illustrate these remarks by speaking to you of the digestion of milk. You are all aware that milk is the most wonderful of all natural dietaries; it contains water, mineral matter and all the various organic constituents—proteids, carbo-hydrates, and fats—which the body requires; and we know that, during an important, although not a long period of life—a period, however, during which the growth of the body proceeds with infinitely greater rapidity than at any other—there is no diet which performs the function of supporting life so perfectly as milk; but then milk, which is supported by most infants and by many delicate invalids, cannot be digested by others. Milk can, however, be subjected to the action of pancreatic ferments, and its proteid matter, which is called Casein, can be altered by trypsin, and can be converted more or less perfectly into peptones, and it is found that Peptonised Milk can almost invariably be supported by the stomach, though it reject all other aliment. Again, from meat we may by similar processes obtain extracts containing all the original proteids in the condition of peptones, which the great majority of invalids can support perfectly well. There are certain cases where meat cannot be partaken of, and in those cases it can be subjected to the process of artificial digestion, so that we may supply to the invalid an already digested meat which the stomach no longer rejects. I bring these facts before you because, in the first place, they are illustrated by a series of preparations in the Exhibition, particularly by those exhibited by Messrs.

Mottershead, of Manchester, and Messrs. Savory and Moore, of London, but chiefly however, because of their immense practical importance, and because they illustrate so admirably the fact which I want to impress upon you, that scientific knowledge is almost immediately applicable to the relief of suffering humanity. Let me perform an experiment to illustrate this peptonising of milk, and the points of greatest difference between it and ordinary milk. Here is some milk which I have heated to the temperature of the animal body by placing it in a bath at about 40° Cent., that is a little over 100° Fahr. Here is a similar milk which I placed at the same time in the bath, and added to it a little bicarbonate of soda, and a certain quantity of pancreatic solution. A great change has come over this milk. In the first place you will see that the peptonised milk has lost some of its opacity, and has become yellow and more translucent; but the chemical change is very marked indeed. I take first of all some of this unaltered milk, and show you by a rough experiment that it contains the proteid matters called Casein. I add acetic acid to it, that is the acid of vinegar, and we find that the milk is curdled. That is one of the properties which milk possesses, that if you add to it an acid the acid curdles it. We know that the milk is also curdled under other influences, as, for example, by the *Rennet-ferment*, of which I spoke the other day, which we find in such large quantities in the true stomach of the calf. I am experimenting with cows' milk; and the acetic acid throws down the casein in large flocculent masses. Now, I take the peptonised milk, and treat it in the same way, and when you come round to look at it after the lecture you will find that no curd has separated; the casein has been converted into other bodies, and a great part of it has passed into Casein-peptone, that is to say, into a body which is not merely soluble in water, but is diffusible, which will be able without any further digestion to make its way out of the alimentary canal of an animal into its blood vessels.

In this process of peptonising there are certain by-products formed. We find, for example, that if the process of peptonising is carried far a very bitter substance is produced. If you tasted the peptonised milk which I have made, you would find it intensely bitter. That is one inconvenience which attaches to the feeding of invalids incapable of digesting milk, or other proteid substances, with peptonised milk, that the process so very readily goes too far, and that there is produced, in addition to peptones, an excess of unpleasant bitter substance. With proper precautions, however, the peptonising may be stopped at a proper point, and then you obtain a milk no longer precipitable by acid, no longer precipitable by rennet, which is found to be almost, if not quite, perfectly digested.

Amongst the products relating to pancreatic digestion, which you will afterwards see on the table, there is one of Condensed Peptonised Milk ; this new and valuable product furnishes us with a preparation by means of which peptonised milk may be at our hand at any time without having to obtain solutions of pancreatic ferment, and without having to go through the careful operation of watching that the process does not go too far. Here is some of this peptonised sweetened milk. When I mix it with water I obtain a liquid almost identical with the liquid obtained by taking any ordinary sweetened milk and mixing with water, only the casein no longer exists as normal casein ; it has passed into the condition of an absorbable peptone. Although this milk has been peptonised to an extent which would render it disgusting if prepared by the ordinary process, because of its extremely repulsive bitterness, it has, by the process of condensation, been rendered perfectly palatable.

I wish to point out to you the importance of these researches on pancreatic digestion in permitting the physician to treat cases of dyspepsia, and of organic disease of the stomach in a way which was formerly impossible ; setting an organ at rest which requires to be at rest, by giving it pre-digested food. The principle,

which is illustrated by this peptonised milk, has been carried out in other cases too. You will find in the Exhibition preparations of Malted Foods of various kinds; in these malted foods the starchy constituents have been pre-digested by the action of vegetable Diastase, so that when given to invalids no digestive efforts are required in order to digest the particular constituents which are present in large quantities.

I must now bring these already too lengthy lectures to a close; but before doing so I must say a few words to give you an idea of the relations of the functions of which I have spoken to the process of digestion as a whole. By the influence, then, chiefly of the gastric juice and of the pancreatic juice, aided by the temperature of the body and by the mechanical movements of the stomach, all the groups of food constituents are brought into solution, or nearly so; and, more than that, they are converted into bodies which possess the power of making their way through animal membranes. As the food passes along the very lengthy intestine, the dissolved constituents of the food are brought into contact with microscopic processes of the mucous membrane, which contain minute blood vessels and minute lymphatics. The soluble contents are absorbed; the proteids as peptones, and the starches as sugars, mainly into the blood-vessels; while the fats, which have been reduced to a fine state of division through the influence of the pancreatic juice, make their way into the commencements of the lymphatics, which are contained in the villi of the alimentary canal.

THE REARING OF

HAND-FED INFANTS.

BY

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SURGEON TO THE HOSPITAL FOR SICK CHILDREN, GREAT ORMOND STREET.

With an Introduction by CHARLES WEST, M.D., F.R.C.P. (*Founder of the Hospital for Sick Children.*)

AUGUST 1ST, 1884.

A LECTURE ON THE REARING OF HAND-FED INFANTS.

By EDMUND OWEN, M.B., F.R.C.S.,

Surgeon to the Hospital for Sick Children, Great Ormond Street.

CHARLES WEST, M.D., F.R.C.P., Founder of the Hospital for Sick Children, in the chair.

INTRODUCTION.

THE CHAIRMAN, in introducing the lecturer, said the lecture was intended to serve as a help to those mothers who, from accident, illness, or the claims of some great duty, were unable themselves to nurse their infants, or were compelled to wean them prematurely. It was not intended for any who, from motives no higher than those which vanity, indolence, or frivolity could suggest, abstained from doing that which was a mother's paramount duty. Still, though he had used those hard words he was sure many who neglected that duty did so from having but a very imperfect sense of the importance of its fulfilment.

With whatever care an infant might be surrounded it was a fact never to be forgotten, that the chances of a hand-fed child reaching the age of one year, were one-third less than those of a child nursed by a healthy mother. It was impossible to give proofs of this from experience derived in

ordinary life, and evidence of it had to be sought from the results obtained at large institutions such as the Foundling Hospitals in France. He would not wish the figures he was giving to be taken as representing anything else than the comparative results of the two methods of attempting to bring up children. The average mortality of children in this country under one year was 14 per cent., while that of the children admitted into the Foundling Hospital at Lyons, in which institution they were not detained even for a day, but were sent immediately into the country for wet-nursing, was 33 per cent. under one year. But the mortality of children admitted into the Foundling Hospital at Rheims, where they were attended with equal care, and were quite as speedily sent into the country, but where they were brought up by hand and were not wet-nursed was 63 per cent., a difference which it imported all to lay well to heart. Not only so, but it must be remembered that when hand-fed children fell sick and died, they died not of any of the ordinary diseases which befell babyhood, but of a purely artificial disease, presenting special symptoms, leaving special appearances after death. A distinguished French physician who was, unfortunately, recently dead, the late physician to the Foundling Hospital in Paris, investigated this subject with the minutest care, and he gave to the condition, which he ascertained was produced by artificial feeding when carried out unsuccessfully, a name derived from two Greek words signifying non-nutrition, unnourished, or, in other words, starvation.

It had been his painful lot, and not very rarely, to hear from broken-hearted mothers who had lost their hand-fed children a confession, not precisely perhaps in the words, but to the effect, that God had given them children which they had starved because they would not break through their habits of indolence, or because they would not for a few months give up that society in which they were admired. That was a grievous confession to be made to one's heart, even if it were not made aloud; and perhaps the mother whose child was thus taken from

her never had another, and lived on to a childless old age when she would want the comforter that child would have been to her if, in its infancy, she had done a mother's duty. It might be said by some "That may be all very true, but why should we live anxious days and spend laborious nights, for the sake of nursing our infants, when we can get wet-nurses for them, and when with a good one a child would thrive just as well as if they nursed it themselves?" But even if that were the case, and he very much doubted it, what was their duty to their neighbour where the wet-nurse herself had a child? Were they not bound to think of the poor woman whose child might be her only pleasure, and who came to them often with an anxious heart and many misgivings to nurse their children? Were they doing right, unless they were compelled by some over-powering necessity in doing this; and if they were compelled to do it, were they not bound (which he was afraid many ladies did not do) to look after that poor woman and that poor woman's child which, perhaps, was being sacrificed, or at any rate endangered, for the sake of theirs?

He supposed most of them knew the story, and it was a true one, of one of the great ladies of the Court of Louis XV., Madame de Tanson, who, when her son, for whom she had never cared in childhood, had risen to fame as the great mathematician and philosopher, D'Alembert, sought to claim him, but he refused to recognise her as his mother, telling her, "Nay, you are not my mother, my real mother is this poor carpenter's wife who nursed me at her breast and tended and cared for me in my infancy." And was not that indeed the case? Were they not, in giving up the nursing of their infants, renouncing not only their mothers' duties but a great part of what should make a mother's joys?

There was one point of remarkable difference between the lower animals and man, and that was that with the greater number of the lower animals dentition takes place early, and the young creature is soon able to dispense with its mother's care, as though it were the object of an all-wise Providence that it should, as soon as possible,

be able to gain its own subsistence and live for its only object, that of perpetuating its species. But in the case of the human being it was far different; the infant had to be trained with care into a man, whose future was not bounded by this world's horizon; his moral as well as his physical qualities had to be developed, and it was for that purpose, no doubt, that an all-wise Providence had decreed that the infant should be dependent for a considerable period upon its mother, in order that the child might learn to cling to her through life with an affection which surpasses all others; she, on her part, caring for her child with an affection which made her, during all its early years, the child's best guide, companion, guardian, and friend. A high duty that! A great privilege! A source of purest joys! And would they abandon those duties and renounce those golden joys for any meaner thing which this world could give them?

Poets had described, painters had depicted, and the very ballad singers in olden times were wont to sing the joys which Mary felt when the blessed Babe was lying in her bosom; and he was sure the ladies present would not prove her degenerate daughters. They would not renounce those great privileges; they would not give up those joys in manner like to hers, for they all must love the highest.

THE LECTURE.

A SHORT lecture on such an important subject as that of the Rearing of Hand-fed Infants will of necessity run the risk of being considered tedious, if only from the amount of dry detail which its consideration must involve; but, what is of greater moment, it will be found unsatisfactory because it must needs be left incomplete.

Boyle remarked that the dim and bounded intellect of man seldom prosperously adventures to be dogmatical about things that approach to infinite, whether in vastness

or littleness. The importance of this my adventure must be characterised by vastness, though it consists of littlenesses which have been too generally deemed unworthy of deliberate consideration or of practical instruction. Whether this my adventure shall completely fail, or, as I will dare to hope, be partially prosperous, will not be absolutely known. This much only is certain, that the lecturer will not feel aggrieved if, on its conclusion, the adjectives "dim" and "bounded" be used to qualify his intellect. With this admission on the threshold, it will be clearly understood, I trust, that I am not prepared to maintain that he who holds views which happen to be in antagonism to those which experience has compelled me to adopt, is of necessity in error. Indeed, I should not be surprised if, at the end of my discourse, several provokingly healthy children were gleefully exhibited who had been reared by hand on plans directly opposed to those on the importance of which I am about to insist. At any rate, my plans shall be found unusually simple and they will be calculated, if carried out with ordinary intelligence, to insure the extension of the greatest good to the greatest numbers of these unlucky infants.

Lastly, by way of preface, I would like to submit this assurance, that my opinions have not found origin and maturity, like certain histories of personal adventure and foreign travel, in the Reading-Room of the British Museum; they are the results of years of interesting work in the Out-patient rooms of a neighbouring institution, in Great Ormond Street, where ill-taught mothers and sickly children much do congregate.

The rearing of hand-fed infants unfortunately is not a matter that can be altogether regulated by definite rules or conducted with mathematical precision; it is an art requiring more sense and science, skill and delicacy than even that of orchid-growing; nevertheless, almost every woman, utterly regardless of antecedents and general qualification, considers herself specially adapted for its successful prosecution, and to the manner born.

Possibly as time rolls on, and women are fully occupied with the cares of office and the affairs of state, men may find this, a new field, opened to them; but in the meanwhile women must be left in undisputed charge of the business which hitherto has not been carried on in a thoroughly successful manner. May I delicately hint, without risk of giving needless pain, that amongst those least suited for the work may often be found the experienced monthly nurse (so called), and the infant's grandmother?

Though my object to-day will specially be an endeavour to improve the surroundings of our vast army of hand-fed babes who are being yearly sacrificed upon the altar of ignorance and incapacity, still, much of my remarks will be found to apply with equal force to those infants who are brought up partially or entirely on the breast.

To show the importance of the subject in question, and its unsatisfactory condition, I may remark that it has been computed that more than two-thirds of those who are brought up by hand perish in infancy or childhood; and, from what I have seen, I am almost prepared to accept the figures. Quaintly, but truly, has it been remarked, that very many little children who should be playing amongst the daisies are sleeping beneath them on account of errors committed in their bringing up.

Probably every one here will admit the truth of this general proposition:—that for the first half year of infancy the mother's milk should be the *only* food. But when this natural supply falls short of the demand, or entirely fails to makes its appearance; or in those cases where the poor woman is compelled to leave her home and her infant, for more than half the day, in order that she may earn money for the support of her husband; or when a lady of fashion discovers that the demands of a Society, in which she is, perhaps, a bright luminary, take up so much of her time and attention as to overshadow and efface the sweet duties of mother-hood, this question must be answered—"*How should the babe be fed?*"

To this the analytical chemist and physiological theorist promptly hands in a solution:—Having taken a specimen of human milk into his laboratory, and found to a decimal the proportions in which its constituents are arranged, he sets to work to build up a food upon the lines of this analysis, which, in its power of supporting infant life, he deems must be at least equal to, if not better than the original article. Then his scheme is accepted by a trading-firm; the food is boldly and attractively advertised; manufactured by the ton, and kept in stock "by every respectable chemist."

As I pass by the street-hoardings, or travel by rail, I cannot but wonder if in those dark days when fresh cow's milk, properly prepared, formed the basis of artificial food, infantile scurvy, rickets, and wasting diseases generally were not less widely spread than they are at the present time.

Specially on this matter would I like to hear an opinion expressed by such an authority as he who has done me the honour of occupying this chair to-day. Than he, no physician can speak from more extensive observation, or greater knowledge; whilst his presence here, may be taken as evidence that his personal interest in the welfare of those little ones for whom he has already accomplished so much continues in undiminished activity.

It is not my desire to tax your indulgent attention by reference to any table of percentage composition of human milk, or of any of its ordinary substitutes; but I must pointedly remark that in human milk there is found no trace whatever of the starchy element of foods, there is nothing like bread, rice, corn-flour, oatmeal or biscuit powder. And surely a recognition of this fact ought to suggest that the young infant has neither the need for such aliment, nor the power of digesting it: such inference would be correct. But the chemist, who is not at the same time a common-sense physiologist, pays no heed to this matter, and even works on as if there must be some error; for in the preparation of his patent food for infants, he often

uses plenty of starch in one form or other. He might almost as well put in so much fine saw-dust.

The proper infant's-diet is animal, not vegetable. Let me briefly call to mind the ingredients which invariably, and alone, are found in human milk, which, for want, at present of a better standard, I find it convenient to take as the model food for babes. These, then, are the elements :— butter, represented by the cream ; cheese, which is represented by the curds, which appear in the ordinary course of digestion, or at other times when milk turns sour ; sugar, salts, and nearly 90 per cent. of water.

ARTIFICIAL MILK.

The best substitute for human milk is obtained by mixing perfectly fresh cow's milk, with an equal quantity of quite warm water, in which a lump of white sugar, and a small pinch of salt have been dissolved. The water is added because cow's milk is, compared with human milk, too rich both in cream and curds, whilst a little sugar and salt are wanted to bring it up to the standard. But even after this dilution there may be trouble with the massive curds which form in the stomach. In such cases the proportion of the water may be still further increased ; and at times, when I have been assured that cow's milk and water will not "agree," I have proved to the contrary by having in the mixture *twice as much water as milk*. Some nurses, when using either cow's milk or condensed milk, appear imbued with the belief that the stronger the mixture given to the babe the more he must necessarily flourish ; and carrying the theory to apparently its ultimate limit, I have known a woman give her tender babe meat and beer. The fact of this particular woman's husband being employed in a public-house can hardly excuse her unphysiological conduct. When, in further addition to their routine studies, all school-board children shall be taught chemistry and physiology, such a display of ignorance will be quite exceptional. At least it should be so.

As the infant grows, less and less water will be wanted,

but until the sixth month no other food should be given. Baked flour and oatmeal cannot be digested, so they cause sickness and diarrhœa.

From two to three pints of the prepared food will be required in the course of the twenty-four hours, and it should be given in small quantities, and at the temperature of the body. To secure this last point the nurse should always put a spoonful of it to her own lips to see that it is "about right;" she need not be armed with a thermometer.

The idea of getting the milk always from the same cow, I have abandoned as impracticable, at least in towns; indeed, if the supply of one dairy do not seem to agree with the infant, it is a good plan to change to a fresh establishment, as there may have been something in the feeding of the cows which rendered that particular sample unassimilable.

At six months the babe may be allowed, in addition to the milk, boiled bread-and-milk, beef-tea, oat-meal, baker's rusks, or Chapman's wheat flour.

Hitherto I have but once spoken of condensed milk in the feeding of infants, but holding strong views upon the inadvisability of its usurping the place of fresh cow's milk in the nursery, I must now speak plainly on the matter. Theoretically, as well as in practice, I am quite unable to see how it is that cow's milk, which has been evaporated almost to dryness, mixed with much sugar to prevent its going bad, soldered down in tin pots, sent on a long journey, and then stored for an indefinite time in the shop-window of an oil and colour-man, can form a *better* basis for the nourishment of hand-fed infants than fresh cow's milk just prepared as I have directed. It appears to me to be a fallacy—a manifest fallacy—that this preserved article can ever afford more genuinely healthy nourishment than the fresh milk. I could as soon believe it as that an intelligent man will thrive better on tinned American beef than on fresh sirloin; and surely the analogy is not over-strained.

Certainly my experience of hand-fed infants is that the

worst-nourished are almost invariably those which have been brought up on the patent foods and preserved milk; even though they may be big, they are generally flabby; the wrist-bones are swollen, and the legs apt to bend; they are often backward too, and are apt to yield themselves a ready prey to the sequels of those illnesses to which the goddess Hygeia is only just beginning to teach us, that we should no longer consider them necessarily heir.

The sailor in the Arctic circle, who subsists on a diet which is perfectly physiological, except for its want of fresh animal juices and fresh vegetables, sickens and dies of scurvy. And so it is exactly, though in rare instances, with certain children in our midst who are being reared without due regard to the need of fresh milk—they may fail and perish of typical arctic scurvy. Fortunately the distress usually stops short of this, for every physiologist has learnt that new milk is a princely anti-scorbutic.

I dare say that all kinds of preserved milk are not equally unsatisfactory as accessories in diet, for some have not had any of the cream removed before condensation. Unfortunate, indeed, are the infants whose lot it is to languish on the condensed skim-milk! How they must long for the fat cream; how grateful to them must be the little dose of cod-liver oil which the mother often prescribes on her own responsibility!

Not many years ago a traveller brought into England a water-weed from foreign parts, as a curiosity; and it has since flourished in our rivers to such an extent as almost to completely choke them in places. So it is with condensed milk; we have got it into our households and are now being overwhelmed with it. Still it must, I suppose, be used; and I see from an article in a journal * of last week that there may yet be a great and profitable future for it.

I read the paragraph as it stands:—

"Condensed milk has been lately extensively employed in connection with what may be called a new industry, that of 'milk-blending,' or, in other words, letting down rich

* *Health;* a weekly journal, July 25, 1884.

dairy milk, so that the analytical results agree with the figures for solids not fat prescribed by the Society of Public Analysts. Large quantities are daily consumed in this way by milkmen, and to such an extent has the trade increased, that condensed milk is imported in churns, especially manufactured for the convenience of dairymen; these churns being returned to the factory for a further supply."

My only hope is that children will not get too much of this ingeniously prepared mixture; far better was the old one of watered milk.

FEEDING BOTTLES.

A most important matter in the hand-feeding of infants is the kind of feeding bottle used. I hold in my hand the old-fashioned and excellent slipper-shaped bottle. And what a good thing it would be, if, in their search for the antique, mothers would revert to the use of this ancient feeder. I feel sure of this, that if a Hogarth of to-day were to paint the idle and the industrious dry-nurse, he would place this bottle in the hand of the industrious one. Whilst the infant of the idle one would be represented as asleep, with one end of a slender india-rubber tube in its mouth, the other end losing itself in an empty feeder, such as this.

The advantages of the old bottle are that the infant can be fed only when the nurse is holding the bottle, when, if the food seems to be coming too quickly, the supply can be remitted for a few seconds. Thus, throughout the feeding, the infant is certain to be receiving the undivided attention of the nurse, so that the supply is always likely to be given at regular intervals and in proper quantity.

There should be two feeding bottles in constant work, one for day and one for night; and after use the bottle and nipple should be thoroughly washed in a little warm water and soda, and then well rinsed in cold water. Till next wanted they should be kept in a basin of clean, cold water.

With this old-fashioned bottle there is nothing to get out of order; no tube to get twisted, or to be tied in a knot, and nothing that cannot be easily kept perfectly clean.

Regularity in the use of the feeder is a most important matter; in the first month it will be wanted every two hours, and then, by gradually increasing the interval, every three, and eventually every four hours.

If the infant is sick after his bottle he should be fed at shorter intervals, and with much less food at a time. Need I say that he should not be fed every time he cries? True it is that the infant has "no language but a cry;" but often the cry means, "I feel already uncomfortably distended," or "I am damp, or cold." Again, we are told that "an infant crying in the night" may merely want "a light." Some mothers have no other way of attempting to allay a cry than by thrusting the nozzle between the lips. Fortunately this measure will often succeed, for all that the infant has been wanting was the necessary stimulus for freeing its stomach of an indigestible load. If he is a good sleeper he may be woke up two or three times in the night, but never then allowed to over-feed.

But to return for a moment to the question of feeding-bottles:—The nurse having filled this long tubed bottle, is apt to put it into the cot by the infant's side, and to go about her business while the meal is being consumed. Often she deposits it in the perambulator, and allows the infant to help himself as he is being wheeled along; and, then, "just to keep him quiet," he is allowed to suck away at the empty bottle, and to take in wind. Indeed, he becomes "a slave to the bottle," and refuses to go to sleep without it. This is in every way demoralizing. Weaning from this bottle is apt to be long delayed, and perhaps not accomplished by the time that the apparatus is wanted to serve for a fresh addition to the family. I have known the weaning delayed until the child has been able politely to ask the mother for his solace. Certainly, well before the expiration of the first year the infant should be entirely weaned, and should be receiving, in addition to the foods

recommended a short while ago, a little under-cooked meat, pounded up and mixed with gravy and salt, or potato similarly treated; and this diet may be varied with an egg, or a milk-pudding. But on no account should he be allowed any wine, beer, tea or coffee, though he may have cocoa-and-milk. Nor should he be allowed to "pick" at bread-and-butter, cakes and sweet-stuff in the short intervals of his regular meals.

WARMTH

One of the chief uses of food is for keeping up the animal heat; and a weak digestion may be spared considerable unnecessary work if the infant be kept always warm; truly it may be starved with cold. He should be clothed all over in soft flannels, and if of a chilly or feeble nature, his cot should be placed near the fire, or at least in a warm room; and, if possible, where the sun can shine about it. Without fresh air and sun-light children, like flowers, pine and droop. The nursery, therefore, should be near the top of the house, at any rate so in towns, for this will be the lightest and most airy situation. And, if practicable, it should have a South aspect, so as to entrap as many as possible of Apollo's life-giving beams. His glorious beams love children's faces; they search them out like peaches on a sunny wall, penetrate the tender skin, and store both in and beneath it a boundless wealth of health and happiness. Whenever I am tending a sick child I make it one of my first cares to get his cot into a sunny corner of the room, for a change in this way often appears to be almost as beneficial as the breath of sea-side air.

I trust that in this I am clearly understood. I do not mean that it is good for an infant to be tied down in a perambulator and wheeled along with its face turned up to a blazing mid-day sun. What I mean is that in England we do not seem to understand the true value and charm of sun-shine (possibly because we have so little personal acquaintance with it). In Italy it is different, and the common saying runs to the effect that where the sun does

not go the doctor does. The sun's rays rob suspicious gases of their evil power; but from all such vapours infants should be jealously guarded; they quickly fade beneath them. Therefore the utmost care should be taken that no sink or closet is breathing near the nursery. Harrowing stories without number may be told of how little innocents have fallen victims to the neglect of these first laws of sanitation. Every thing near babies should be sweet and fresh, and there should be no carpets, bed or window-hangings to interfere with the free circulation of air.

The bed should be warm before the infant is put in it, and a warm bottle wrapped in flannel may, in the cold weather, be tucked beneath the clothes. But by no means should the infant be taken for the sake of warmth to sleep in the mother's bed; it is a highly dangerous practice. The coroner for Central Middlesex informs me that, in his district alone, 120 inquests are held annually on children who, sliding under their mother's body, or creeping thither for warmth, have been fatally overlaid. He also tells me that in Germany, it is criminal to allow the young child to sleep with the adult.

In the American edition of Æsop's Fables one reads of a kind-hearted she-elephant, who heedlessly set foot on a partridge, which she crushed to death within a few inches of the nest containing its callow brood. "Poor little things," said the generous Mammoth. "I have been a mother myself, and my affection shall atone for the fatal consequences of my neglect." So saying she sat down upon the orphaned birds.

The moral which Mr. George Washington Æsop draws from this affecting anecdote is, that it is not every person who should be intrusted with the care of an orphan asylum; but personally I venture to think that all the moral has not thus by any means been exhausted.

DRESS.

Taste in the dress of infants, as in all things else, should be in subservience to utility. Surely in this case the first

use of dress should be warmth; but unfortunately the converse of this proposition seems generally to hold good.

Look at the infant who has just emerged from long clothes; on the most treacherous day in March or November, you will probably find him in a cold-looking white cotton frock, which is cut low in the shoulders and high in the arms; whilst the little strip of sleeve is made narrower yet by being tied up with ribbon; so the arms, neck, and much of the delicate chest are left bare and chilled. His thin cotton socks fall down from his ankles, and his legs and thighs are left exposed to every change of temperature. The effects of this wicked—I had almost said—foolish fashion, must be baneful enough in the upper classes, whence probably, it took origin; but with the poor, whose children are constantly in the way of draughts and exposure to cold, the results must be much more disastrous. A child's clothes should be warm and loose, and should not, after the first few weeks at any rate, include that strange vestment which is wound round and round the trunk. Warm woollen stockings should reach well up the thighs, and drawers should over-lap them; and if the latter be of linen or calico, flannel may, in cold weather at any rate, be worn beneath them. The cinglet of merino or flannel should reach right up to the neck, and should have long sleeves, as should also the frock.

The more delicate an infant the more the need for all this tender care; in Canada and America generally this important matter of clothing is far better understood than it is with us. Thus to dress a child is not to coddle it; it is but to carry out a scheme which is practically illustrated in the case of the bird, who lines her nest with down, and spreads her feathers over her young, until Nature has had time to fledge them, and so to enable them to generate warmth for themselves, and exercise their growing limbs in flight.

It would be interesting to know how this present style of infants' dress was evolved; and I would venture to

commend the subject to the attention of the Hon. Lewis Wingfield.

If a surgeon wishes to inspect a little arm or leg he finds the part all too readily exposed ; but if he would examine the base of the infant's chest, hooks and eyes, tapes, buttons and safety-pins have to be undone, one after another. Garments are thus loosened layer on layer, endless bands of girth are unwound, and at last the skin is reached.

The middle part of the body has been converted, as Mr. Treves remarks, into a torrid zone, whilst its poles have been left frigid. The amount of clothes which have been thus heaped upon the infant should, in bulk, be amply sufficient ; no scheme of extension of investment is demanded, but rather one of redistribution.

Fashion has been likened, I dare say, to Juggernaut's car : and surely in the matter of the feeding and clothing of infants many thousands of victims are yearly cast beneath its heavy wheels ! But the huge sacrifice attracts no remark ; the great black image is dragged onwards.

WASHING.

A necessary health measure is the washing of the babe in warm water at a regular hour in the morning and evening. He should be washed all over with soap, except, I should perhaps add, his eyes. Thus the pores of the skin are kept free and sweet. It should be clearly understood that an infant cannot be hardened by being bathed in coldish water. From a carrying out of this harmful idea the weakly ones are cut off, whilst only the fittest for existence can survive. The mother, who happens to have reared one of these survivals, shows it as an example of what cold baths can do, whilst envious neighbours miserably fail in their ill-advised attempts at rivalry.

For insuring appetite, digestion, and sleep, the infant should be taken out of doors each day that the weather is fine; and every day, unless a bitter wind is blowing, or it is foggy, the window should be thrown wide open for a while, as fresh air in the house is absolutely needful.

SLEEP.

And now it is time, I think, to get this healthy, happy hand-fed infant to sleep. And for this purpose, let me beg that he is not swayed about in the nurse's arms, rocked in a cradle, or patted on the back. Though a resort to one of these popular nursery measures may not, after he has grown accustomed to it, make him actually sea-sick, still the habit has nothing more than custom to recommend it. It is, or should be, quite superfluous; sleep should come naturally, and, like the meals, at regular intervals. A well-brought-up infant should close its eyes like a mechanical wax doll as soon as it is laid down for sleep.

Cradle-songs and lullabys may be left entirely for poets and musicians, to whom, indeed, they seem indispensable. Never more should the small hours of the night (nor the wearied father) be disturbed by them.

It was, I believe, only a home-sick sugar-planter who cried "Rock me to sleep, mother." And I do not imagine that if a babe could speak he would ever be heard repeating that request.

And here, in ending my discourse, let me compare it to an ill-made net, in which the irregularly-sized meshes are represented by the many faults of omission and commission. Some threads will be found unduly loose, whilst others are, perhaps, drawn too tight; still I have little fear of the net breaking under the test of practical experience. Indeed, the greater the strain that it may be thus called upon to bear, the more productive shall be reckoned this my cast.

And I will further add, that if this grand Health Exhibition accomplished no other work than that of directing some measure of public attention to the unsatisfactory environment of our thousands of hand-fed infants, history would still have ample justification in regarding it as one of the most important national successes of the 19th century.

Dr. DANIEL said they had not only to acknowledge their indebtedness for an extremely interesting paper, but to

congratulate themselves on the presence of so distinguished a children's physician as their chairman, to whose observations they must all have listened with the greatest interest. Mr. Owen had alluded to the fallacy, so prevalent in London, of getting milk from one cow. It fell to his lot some years ago to visit the cowsheds of Kensington, and he went with a committee to one of them which was most beautifully fitted up, and where there were 8 or 10 cows. The man was asking for a license for another shed on the other side of the road, where he had a single cow; and on being asked what on earth he wanted with it when he already had so many in the other establishment, he replied that he "wanted to shew the ladies that all the milk came from one cow." No greater fallacy could exist than that all the milk sent out in London in sealed cans, as it was, could by any possibility come from one cow. Many of the London parishes unfortunately did not possess analysts, because the Act only said that the Local Boards "might," not that they must, appoint them, and consequently much of the milk that was supplied to the poorer classes was not analysed at all; and even in Kensington, which was supposed to be one of the best managed parishes in the world, samples of milk were constantly being brought in which were distinctly adulterated with water. Unfortunately a sufficiently high standard for milk was not fixed by the authorities at Somerset House; they admitted too high a percentage of water, though the adulteration of milk by the addition of water was not so objectionable as other forms of adulteration. He was an ardent advocate for the use of the mother's milk in the first place; secondly, of good cow's milk, fresh, pure and unadulterated; and thirdly, if *neither could be got*, he must say he had seen very good results from the use of condensed milk. The lecturer had most happily pointed out the evils of the patent feeding bottles which could be bought for 1*s.* or 1*s.* 6*d.*, and if ever there was a curse of civilisation it was that form of bottle. The old-fashioned bottle was much the best, and he believed more children died from the use of those patent bottles

than from anything else, because, no matter how careful a nurse might be, it was physically impossible for her to keep them clean and sweet. Of course too great care could not be taken in the general sanitation of houses from this and every other point of view. He did not quite agree in what the lecturer had said about clothing children; he was not in favour of coddling them, and he must say he liked to see their arms and legs bare. With regard to mothers sleeping with their babies, that was a very difficult question to deal with. As to the question of sleep, children should be trained up in the way they should go, and then there would be no difficulty in getting them to bed and at once to sleep.

Mr. Owen thanked the audience for their attention, and Dr. Daniel for his kindly criticisms.

The CHAIRMAN commended Mr. Owen's remarks to the consideration of every one who had to do with infants, and one great lesson to be learned from them was the great importance of attention to small things. They all remembered what Solomon said, "He that despiseth small things shall perish little by little;" and in nothing was a disregard for small things more speedily or more severely punished than in the rearing of children. Mr. Owen had been good enough to ask him to say from his experience whether within recent years rickets and other forms of children's diseases had not increased greatly; but he must be pardoned for suggesting that he was not Methuselah, and before one could say anything on that point, one would require an experience, not merely of 20 or 30, but of some hundreds of years, and he could hardly, therefore, give a positive answer to the question. They knew, however, that on the whole the life-rate had increased, and that infant mortality had diminished, but it would be a wide question to go into, to discuss all the causes which had brought about that happy result. He was quite certain that it was a matter of great importance that in dealing with

young children they should, as far as possible, be brought up on milk food in their earlier months, and that great care should be used in the addition, even after six months, of any kind of farinaceous food, which should be given carefully and experimentally. Sometimes one form of such food suited children and sometimes another, and a positive rule could not be laid down as to which kinds of food were the best or least mischievous; but his advice would be to eschew them all until the baby was six months old.

As regarded the use of condensed milk no doubt one of the reasons why it was so much used was the dearness of cow's milk, and they must bear in mind, not merely the condition of those who were fairly-off in the world, but that of the very poor. He agreed most heartily with what Mr. Owen had said with reference to the old-fashioned and the new-fangled feeding bottles, and if anything that had passed should tend to throw the latter into disuse the meeting would certainly have done good. Much depended in bringing up young children upon the degree in which poorer mothers were taught, and in that direction he had much faith in the efforts of those ladies who in recent years, and quite within his own recollection, had carried out the system of mother's meetings which were a blessing wherever they were instituted. Let their object be, as he believed it was, not simply teaching their poorer sisters the highest rules of conduct, but also their more domestic duties, and the proper methods of managing their infants which had so much to do with the increase of morality and happiness, and the propagation of true religion.

PRACTICAL DIETETICS,

ESPECIALLY IN RELATION TO

PRESERVED AND CONDENSED FOODS.

BY

PROFESSOR F. DE CHAUMONT, M.D., F.R.S.

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A LECTURE ON PRACTICAL DIETETICS, ESPECIALLY IN RELATION TO PRESERVED AND CONDENSED FOODS.

By PROFESSOR F. DE CHAUMONT, M.D., F.R.S.

The Rt. Honble. Sir LYON PLAYFAIR, K.C.B., F.R.S., in the chair.

THE subject I have been asked to address you upon to-day is entitled Practical Dietetics, especially with regard to the use of preserved and concentrated food. The somewhat pompous expression Practical Dietetics simply means what we are to eat and drink. This is a point that to many appears a simple enough matter, and a great many persons have simply to eat and drink what they can get. But on this matter (as in all other points with regard to life) we require for the proper arrangement of diet the knowledge of certain principles to guide us, and it has been for a number of years past the object of inquiry by a great many scientific men to determine the proper constituents and proper distribution of articles of food. Amongst these gentlemen none has been more indefatigable or rendered more valuable service than our distinguished Chairman to-day. In earlier times the medical and physiological inquiry into the subject of food was very little understood, but it still is a very curious fact that in every case where people of all nations and classes have had an opportunity of getting proper food they have almost invariably, I will not

say by instinct, but probably by practical experience, selected that form of diet and that arrangement of food which appears best to suit the position in which they are and enable them to make the best use of it. By analysing all the different diets of nations of the earth this remarkable fact comes out that where the articles can be procured the diet has generally formed a good diet for the position in which the individual is placed.

Now, the objects for which we take food are various. In the first place we require food of a certain character, which is known as nitrogenous food or albuminates, for the purpose of building up the tissues of the body in the time of growth and repairing them in the time of adult life and old age. And, secondly, we require other food which is generally called non-nitrogenous or carboniferous, including fat, starch, sugar and the like, for the purpose of consuming these in the body by means of the oxygen in the atmosphere, and so getting that amount of energy which is necessary both to support the animal heat of the body and also to produce actual visible practical work. Besides that we require other substances, such as mineral salts, which are absolutely necessary for the carrying on of the functions of the body; we require them for the purposes of digestion, and also for the purpose of regulating the way in which the different constituents of the food are taken up and assimilated. And in addition to all these we may say there is still another class which has been generally included among the carboniferous, and that is the class of vegetable acids, such as citric acid, tartaric acid, and the like, which are present in all fruits and in most vegetables combined with certain bases. They perform a most important function in the system, and the absence of them produces a disease which used to be well-known in former days, the disease called scurvy, which has by no means disappeared from the community at the present time. Now, in order to determine what constituents of food are absolutely necessary it was shown by the late Dr. Prout, one of our first English organic chemists, that milk represented most accurately

the only form of food which was able to support animal life without any addition; and the composition of milk consists, out of 100 parts, of a great deal of water—86·7; 4 per cent. of albuminates in the form of cheese; 3·7 of fat in the form of butter; about 5 per cent. of what we call carbo-hydrates which include starch and sugar, represented by milk sugar; and, lastly, a small proportion, about ·6 of salts or mineral matter. Now we are all perfectly familiar with the fact that the young of every animal, including man, ought to be nourished solely from milk derived from the parent; and on that milk they can grow and flourish and ultimately become healthy and strong. Therefore it has been concluded, and justly so, that milk represents in this way the main constituents of diet which are necessary for life.

But when we consider the relative proportion in which these constituents are present in milk we find the proportion is not such as would be suitable for the life of adult people. On the contrary, in cases where we are obliged for medical reasons to restrict people to a diet of milk alone, it is undergone with very considerable difficulty, because to get a sufficient amount to support a man we require to give a very large quantity—something like 9 or 10 pints of milk a day, which is an immense amount of liquid for the human stomach to deal with. Therefore, although we admit that milk gives the best form of diet; that it gives all the necessary elements of diet in the main; yet the proportions are not such as would be proper to give to adult people for the ordinary purposes of nutrition. We have a disproportion chiefly in this way that there is much too large an amount of nitrogenous matter and fats, compared with the carbo-hydrates. In fact we ought to give more carbo-hydrates, such as are generally given in ordinary diet in the form of starch, to get a diet which will suit most individuals. I am sorry to say that a diagram I intended to have here to show the constituents of a standard diet has not arrived; but I can illustrate it by this diagram, giving the diets of different armies, which was put

up to show what ought not to be the arrangement of diet.

DIETS OF EUROPEAN ARMIES IN WATER-FREE FOOD, IN OZS. AVDS.

	English.	French.	Russian.	Austrian.
Albuminates . .	3·86	4·33	4·02	3·73
Fat	1·30	1·27	1·09	1·64
Carbo-hydrates. .	17·43	18·04	19·62	17·00
Salts	0·81	1·00	1·50	1·00
	23·40	24·64	26·23	23·37

The average of these diets, which differ but little among each other, shows the following constituents: The nitrogenous or albuminates 4; fat 1·3; carbo-hydrates 18; and salts 1. In a proper diet there ought to be more albuminates, two if not three times as much fat; but there is too large an amount of carbo-hydrates in this dietary for the rest of the constituents, and a very much larger amount than we find in milk. But this is the direction in which the chief change takes place in arranging diets of adult people for the ordinary business of life, in a proper standard diet for men to go through ordinary daily work, viz., a larger proportion of starchy matter. We generally require 4½ to 5 ounces of what is called albuminate food, about 3 of fat, and about 14 or 15 of starch and sugar, and a small quantity, about 1 oz. of mineral matter or salts, the whole making up about 23 ozs. of solid food.

One point I must refer to here which bears strongly upon the question of concentrated or dried food. We must bear in mind that all so-called solid food that we have to deal with contains a very large amount of water. Even the very driest substance we have to deal with, such as a dry ship's biscuit, which does not appear very watery, still contains a certain amount of water, about 8 per cent. Even flour, which seems a dry substance, contains something like 15 per cent, and so on. There is another table on the wall which will show the large amount of water contained

in the great many ordinary articles of diet which are used for usual dietary purposes. For instance, every pound of butcher's meat, a beefsteak for instance, which when we buy we think is solid food, contains about 75 per cent. of water, so that there are only four ounces of actual solid food in it. Take again a potato—a pound of potatoes is exactly in the same position—there are only four ounces of actual solid matter in it; and if we go to other substances such as succulent fruits and vegetables, we find even a greater amount. In fact in the average composition of cabbage, for instance, there is more water than in milk; although cabbage is apparently a solid article it contains about 91 per cent of water; and fresh onions even more—as high as 94 per cent—whereas good milk contains only 86 to 87 per cent. Now this is a matter of very great importance, and as the different articles of diet vary so much in the quantity of water they contain, it is obviously impossible to give anything like a scientific statement of the amount of food that is necessary, unless we make that statement disregarding the water which is swallowed with the food. Consequently, we make all our statements of this kind in what are called terms of water-free food; that is taking the amount of albuminates, carbo-hydrates, fats, and so on, we know to be present in an article of food, excluding the water from it. Therefore when we say a diet consists of 23 ozs. of food we mean food theoretically water-free, that is actual solid matter which cannot be reduced any further by the action of drying or any means whatever.

Now let me refer again for a moment or two to the functions of different articles of diet. I have already pointed out to you that albuminate food which contains nitrogen is necessary for building up and repairing the tissues. We have a body which is exceedingly remarkable in this point, that while we can consider it with great truth as equivalent to an ordinary mechanical engine, it has this great peculiarity about it, that while we stoke the engine with fuel we also carry on its repairs without

stopping the machine, and the repairs are carried on by means of this nitrogenous food. Nitrogen, which forms four-fifths of the atmosphere, forms a very large constituent of all our tissues whatsoever. There is not a single tissue, fluid or solid, which does not contain nitrogen. But there is another very remarkable function that this nitrogenous food seems to exercise. This has been proved experimentally; it acts not only by repairing the tissues, but also in a remarkable way in determining and controlling the absorption of oxygen from the atmosphere through which all the chemical changes go on in the body which are necessary for existence. Now, this has been shown by feeding animals upon food deprived to a considerable extent of nitrogen, and under these circumstances the functions have not gone on; the proper amount of oxidation of the non-nitrogenous food has not taken place. I may give a very curious instance to this effect by referring to the case of the well-known Mr. Banting, whose corpulent condition was a matter of common talk some years ago. This gentleman was an undertaker in St. James' Street, who had the misfortune to grow so fat that he weighed 300 lbs., and could only go downstairs backwards. He tried a great many things to reduce his corpulence, and at last he took the advice of his medical man, Dr. Harvey, who suggested that he should live in a certain way, for instance, that he should give up to a large extent fats; to a still greater extent sugar and starch, and increase the amount of nitrogenous food. The result was, that within a reasonable time he reduced himself to the size of a stout but still a moderately stout man. Now the action in this case was two-fold. In the first place he cut off the sources of fat, and in the second place he took more of the particular parts of diet which determine the assimilation of oxygen, and its union by combustion with the non-nitrogenous food. The functions of the other parts of our diet, viz.: the fat and the starch and sugar, are also more or less complex, but the chief action is that they should undergo oxidation, and by that means produces a certain quantity of heat which is

either retained as animal heat in the body, or turned into external physical work in the ordinary work of life. But there is also another function which starch and sugar perform, that is the production of fat in the body, because the fat we take in our food by no means accounts for all the fat that we have, but a great deal of it is produced by the conversion of sugar into that material.

I have referred already to the function of the vegetable acids in maintaining a certain condition of the blood. Now, if the blood is in a proper healthy condition it is alkaline, that is to say that it will unite with an acid, that it will turn some vegetable colours green, and other vegetable colours brown, and so on, but if it gets into an unhealthy condition, and chiefly in consequence of being deprived of vegetable food in that particular form, then it becomes less alkaline, and in consequence gets into a fluid condition, does not coagulate as it naturally would when it is set free, and the result is, the disease we know in its extreme form as scurvy. Now, this disease in former years was the scourge of our navy, and it is on record that the channel fleet in the middle of the last century had sometimes come into Spithead with no less than 10,000 men disabled by scurvy alone; and one of the reasons why the enormous hospital at Haslar was built to hold 2,000 patients was on account of the tremendous stress put upon all hospital accommodation by the enormous number of scurvy patients. This condition of things was remonstrated against by the medical officers of the Navy, who pointed out the remedy at hand by the use of vegetable acids a long time before it was adopted, but as soon as it was adopted the result was magical. Scurvy disappeared from the navy altogether, and that immense hospital at Haslar was left with only a few cases compared with what it was intended to accommodate. But I should mention that scurvy has by no means disappeared entirely, and so far is it from disappearing, that if cases are carefully investigated in ordinary life, even among the better classes, we shall find symptoms of scurvy from time to time. A great many

people dislike vegetables, and even dislike fruits, and neglect the use of them. Others from sheer ignorance do not use them, and the result is that again and again diseases that are apparently caused by quite other means are aggravated and complicated by a certain amount of this scorbutic taint. I have seen cases of this sort myself, and I know other physicians who have told me that cases have come under their notice.

The remedy is very simple, the use of fresh vegetable food or its equivalent in lime juice or other forms of vegetable acid.

Now, it is a very remarkable thing that, although we have certain knowledge of the principles of diet, and know that a certain amount is required in certain proportions in order to get proper results, that we should find, in every case where a corporate or official diet is arranged, dietetic errors occur, and always in the same direction, and I cannot point to a better instance than those four columns of diets in the principal armies of Europe, which show very clearly how this is the case.

Take the English army's diet; in the first place the amount of albuminate food, as given in the usual diet, in something under 4 ounces. Now, in the proper diet for a man of the ordinary size and weight of the British soldier, he ought to get at least one ounce more than this. In the case of fat, on the other hand, instead of getting 3 ozs., which he ought to get, he only gets a little under $1\frac{1}{3}$ oz. He gets rather more starch than he requires—$17\frac{1}{2}$ ozs., whereas 14 ozs., or 15 ozs., would be quite sufficient if he got other articles. The salts are practically pretty near the amount required. If we look along these columns of diet we find that with very small differences in dietary, the results are exactly the same in the different armies. In the French army we have the same deficiency in fat; a little more albuminates, but this is due not so much to the increase of meat, but to the greater use made in France of leguminous foods—that is, beans and peas, which are very nutritious. The same excess of carbo-hydrates exists. In the Prussian

army we have almost identically the same condition of things, but the Prussian soldier gets only 1 oz. of fat: and the same is the case in the Austrian army. If we were to examine the dietaries of prisons and other places, we should find the same mistake runs through them all. Now the cause of this is in the first place ignorance; and in the second place, the fact that these particular articles of diet are rather dearer than the others, and consequently a very considerable increase of expense would be incurred if they were to be ordered. Some years ago there was a considerable movement for getting a larger meat ration for the English soldier, which I certainly think he required, but on calculating the amount of the increased expense which would be incurred, taking the whole of the army, it was found that it would come to pretty nearly half a million per annum; and this was so considerable an addition to the estimates that it would have been a very bold Chancellor of the Exchequer who would have proposed to introduce it, at least without considerable preparation of his audience. The English soldier is in one way somewhat better placed than his brother in other armies; he has a little more pay, and consequently he can spend a little on additions to his food, which he generally does; but in foreign armies the soldiers get very little pay, and consequently they can have very little addition to the actual diet which is provided for them, and therefore they no doubt suffer in consequence.

Now in reference to the question of preserved and concentrated food, this is a point which is very important to all the community, but especially important for public institutions, for troops, and the like, and if the use of this form of food can be carried into effect, the result will be highly beneficial in many ways. In the first place, we can save to a large extent food which otherwise must be wasted for want of a market near the spot. Secondly, we can provide in case of deficiency of ordinary food, wholesome forms of food which can be easily used and properly assimilated. In addition to that we can get ready under

certain conditions particular articles of diet which are not immediately obtainable, but which are necessary for the preservation of health. There is, however, a certain amount of difficulty connected with food of this description, and a good deal of confusion arises with regard to its nutritive value. It is necessary to draw a very distinct line between food that is merely preserved and food that is concentrated or dried. In food that is merely preserved what is done is to take the food generally cooked to a certain extent, and seal it up so as to retain it in that condition. Under those circumstances there is no concentration; it is simply preserving the food from change in its cooked form. On the other hand, when we come to deal with food which is concentrated, we do this by driving out a large quantity of water; and therefore a ration of this food is very much more nutritive, weight for weight, than a ration of ordinary food. But it is necessary we should bear in mind that there are these two different conditions, because I have known the mistake made of looking on merely preserved food as equivalent to concentrated or dried food weight for weight. On one occasion I remember where certain vegetables ran short and preserved provisions had to be resorted to, it was proposed to divide the rations as if those referred to dried food instead of merely preserved, and the consequence would have been that much too small a ration would have been given, but fortunately the mistake was discovered in time.

Now there are various ways of preserving and preparing foods. In the first place if we take food that is simply dried, which has been a very common method of preservation in all ages, we find this can be done with tolerable ease, and will keep to a certain extent the nutritive properties of food intact. As regards meat, for instance, a familiar form of this is the dried meat used so largely in South America under the name of Charqui or Tasajos. It is simply dried in the sun, and remains sweet, and does not undergo change for a very long time. Making use of this Dr. Meinert of Berlin, a very scientific enquirer and manu-

facturer of preserved food, has instituted a manufactory for a particular meat powder (Fleisch Pulver), derived to a large extent partly from this dried meat of South America and partly from fresh meat obtained from different parts of Europe where it is cheap, and the result has been to produce a form of meat which has undergone apparently very little change in the process of drying and preparation, which can easily be applied in various ways for dietetic purposes. I am sorry there is no specimen here to show you, but it is really a very valuable form of food.

Then as regards the drying of other materials, such as vegetables; that is familiar to everybody in the form of Julienne, so commonly used for making soup, where we have the vegetables dried up, but they take up water, and swell out again to their natural form, and make a very useful article of diet. There is, however, one point that we must bear in mind, that the drying can only be carried to a certain extent.

We sometimes hear people talk of concentrated food that can be carried in the waistcoat pocket, or even in the form of a small lozenge, to last for twenty-four hours. This is all mere romance. A man must have a certain amount of food, or he cannot go on working, or even exist. The smallest amount of food necessary for existence is represented by about fifteen ounces of water-free food—nearly a pound, and that is the lowest weight it can be reduced to; and if you take the amount required for a labouring man's food, you cannot reduce it below one-and-a-half pound theoretically. There is another point, however; this is merely the theoretical quantity; but if we were to drive off all the water in this way by a process of drying, we should leave the food in such a state that it could not be taken up and assimilated by the system. On one occasion I had sent to me for examination some samples of what was called meat biscuit, which was proposed to be given to troops on a campaign. It was said to contain in a single biscuit, or perhaps two, food sufficient for a whole day,

considering it contained a large proportion of meat. On examining this biscuit, I found it did contain some meat, as was stated ; but the meat had been dried to such an extent that it was almost in a vitreous form, like glass ; it broke with a conchoidal fracture like glass or flint, and even after many days' soaking in hydrochloric acid, I was quite unable to effect much change upon it. This was naturally not an article of diet to be supplied to our unfortunate troops on a campaign. That is a danger which must always be guarded against in the case of reducing food to a small bulk by means of drying.

Then comes the question of the concentration of articles of food by removing the water to a certain extent. This really forms the method of drying most kinds of food ; but when it is spoken of in the form of concentration, it generally refers to those liquid foods which are in common use, such as milk, beef-tea, essence of meat, and so on. Under those circumstances concentration can be carried to a considerable extent, and mi can be reduced to a small bulk and kept properly sealed for a considerable time without undergoing very much change. The only change it does seem to undergo is occasionally the separation of the butter from the rest of the milk, but this is immaterial so long as the milk remains sound.

As regards the other substances, concentrated beef-tea and essence of meat, it is desirable to say a word. You will see in the market tins and boxes of essence of meat which purport to be the entire strength of a certain number of pounds of meat. In fact it is stated that one ounce of essence of meat, for instance, is the entire strength of no less than two pounds or thirty-two ounces of meat itself. Now stated in this way this is entirely misleading. What this essence of meat really is, is the juice of the flesh, not the meat itself at all. Many years ago, an eminent French physiologist, Majendie, made an experiment which clearly shows that this essence of meat is not a nutritious substance in the proper sense at all ; because by making a strong rich soup from meat, and feeding a number of dogs with this

soup alone, and a number of other dogs with the rejected fibrine, the result was that the dogs fed on the rejected fibrine lived and flourished, whereas the others all ultimately died. I had experience of this myself many years ago. I tried with a friend, to see how long we could live on this essence of meat, taken instead of ordinary albuminate food, on the supposition that it was equally nutritious ; and after a very few days we were reduced to a state of considérable inanition, and exceedingly bad temper, which was immediately improved by the addition of a little more proper food, especially a little butter. The substances called essence of meat and beef-tea have, however, a considerable value ; but it is more as stimulants and aids to digestion—food regulators, in fact—than as actually providing nitrogen or nitrogenous matter itself. Therefore we should look upon them in this light ; they form very excellent bases for soup, and for different other articles of diet, but alone they cannot be considered as really nutritive. At the same time the use of these substances is exceedingly valuable in cases of extreme fatigue, and the administration of meat extract to troops on a long march has proved to be of great value, mixed with a proper amount of water, and sometimes added to a little wine, it has raised the flagging energies in a way that I do not think any other substance would probably have done. There are forms, however, of fluid meat which are somewhat different to these. There is here a bottle of so called fluid meat, which professes to contain not only the juices of the flesh, but also the fibrine dissolved. If this is the case then it is a form of material which certainly provides actual nutriment as well as the stimulating effect due to the juices of the flesh alone.

The usual method of preserving food. however, to at least a very large extent, is the method of preserving it in its own natural condition without concentration, by keeping it from the action of the atmosphere ; when we say from the action of the atmosphere we mean simply this, that the atmosphere contains a large quantity of minute moving

bodies called bacteria, bacilli, and so on, which all belong to a certain low class of vegetation, which have the power of exciting fermentation and putrefaction in organic matter; and it has been proved by experience that if these bodies can be kept out of an article of food it can be kept for almost an indefinite time without undergoing change. This principle has been applied with great results by Sir Joseph Lister in the treatment of wounds and other surgical complaints, and by carefully excluding all these minute bodies of the atmosphere he has been able to put an end to a large extent to the various surgical diseases such as hospital gangrene which were formerly the scourge and opprobrium of hospitals. This has been done even in some of the continental hospitals, where general cleanliness has been but little attended to. By this method an immense improvement has been made, and diseases have been prevented which otherwise would have carried off a large number of patients. Now this action of the minute bodies which takes place in our own system, also takes place in various forms in all sorts of organic matter, and if, as you know, you leave meat or any other substance exposed to the air, in a very short time putrefaction begins, and the substance becomes very rapidly unfit for use. There are several ways of preventing this: in the first place, the mere act of cooking alone is sufficient at the time to destroy all the putrefactive particles in the meat; and if after that we can prevent the attack of further particles from the atmosphere, then we can preserve our food for almost an indefinite period. That is at the base of all the different forms of preserved food, some of which I have on the table here. The food is first thoroughly cooked, then, while it is hot, and the steam is issuing out of a small aperture in the corner, the whole is sealed up and preserved for further use. In that way we can have all sorts of articles of diet preserved, and they form very valuable resources in many cases. There are, however, in some cases, dangers connected with these articles of diet. In the first place, if the food itself is not

in good order when put up, it will continue to putrefy even after it is sealed. Then, in the second place, the food, although not actually bad in the sense of putrefying, may be unwholesome in the sense that it is from animals diseased in various ways. Lastly, some dangers may arise from the materials used in the packing and putting up of the article. With regard to the first point, if the food is not thoroughly cooked, or if after being thoroughly cooked it is exposed to causes of putrefaction, it will continue to putrefy, even when shut up and enclosed in the tin, or in any other way. A very good way of testing this with regard to tinned food is to see whether the top of the tin, for instance, a tin of condensed milk, is flat or depressed. If the top is flat or depressed, it shows that no air has got in, because the expansion caused by boiling has expanded the air at the time of sealing up, and then, as it cools down again, if the whole is air-tight, the top of the tin, the most yielding part, will sink down to a certain extent. If, on the other hand, you find the top bulging out, you may be pretty certain decomposition has gone on, and when you open it you will probably have a gush of extremely foul air, which will at once warn you of the condition of things. Then again, if food is put up which comes from a diseased animal, or in any other way tainted, disease may arise in consequence of eating it. This is especially the case in meat which is suffering from measle, that is, the larva of a form of tape-worm; or meat which contains the flesh worm, which is unfortunately found from time to time, especially in the flesh of pigs. Under those cases, if the cooking has not been very thorough, these creatures will develop in the human body, and produce painful, if not fatal diseases. But besides that, a danger may arise from the material which is used in sealing up the tins. Now where proper metal is used, and it is properly soldered, there is not very much danger. In the old method of putting up tins with rosin solder the material was tolerably free from any danger in that way, but in some cases lead has been found in articles of preserved food, and latterly I believe, particularly

in America, the soldering has been done by another method, which involves the use of chloride of zinc, which is an exceedingly poisonous substance, and if any of that gets into the meat, there will certainly be a bad result. Zinc poisoning is not so well known as lead poisoning, but we have had reason in recent times to recognise its presence from the action of different acids from articles of food on zinc vessels, especially on so-called galvanised iron vessels, which are simply iron vessels dipped in molten zinc, which take a thin coating of that metal. Under some circumstances this is attacked by articles of food kept in them, and the result is zinc poisoning is produced, which can now be easily recognised.

There is another method, however, of preserving food which has come into use of late years, and that is by the addition of certain substances to the article of food, to prevent the development or action of putrefactive particles or so called Bacteria. Various substances have been recommended for this purpose, and amongst others, Glycerine, Borax, Boracic Acid, Salicylic Acid, that is acid got from Willow bark, and some other substances, and they have been tried in various ways. It has been found with regard to the last, Salicylic Acid, that this is not by any means a desirable thing to take into the system as a habit; and impressed with this view the French Government have lately passed a very strong enactment against the use of this substance, which it had become the custom to introduce into wine to prevent it undergoing the change which some of the lighter wines are very apt to do in times of change of temperature and on carriage. The other substances I have mentioned, Glycerine, Boracic Acid, and Borax, or Biborate of Soda, are less harmful; Glycerine in fact itself is not the least harmful. It is a substance which may be taken into the system in considerable quantities. It is easily digested and oxidised; and even persons who are unable in certain conditions of health to take sugar at all, may take glycerine with freedom. We know that if we immerse substances in glycerine, they can

be kept an almost indefinite time without undergoing any change. Again, Boracic Acid and Borax are very deadly to all low forms of life. None of these can exist at all in a solution of either substance, and in consequence this has been made use of by adding these substances to the articles of food, such as milk and various other foods which have to be preserved, in order to prevent the development of these minute organisms. Now although this is certainly successful to some extent, it is a question whether it is advisable to continue to take into the system substances which are certainly deadly to one form of life, and may, so far as we know, have some very undesirable effect on the human system. This point still requires investigation. These two I have referred to have been joined in a substance called Boro-glyceride, which has been made the subject of a patent, by Professor Barff, and he has succeeded to a considerable extent in preserving articles of food. A small quantity of it may be added to soup, for instance, or to beef-tea, or milk, and will preserve it for some time without its undergoing change, which would be of great value in hot weather; but on making enquiry in one of the London Hospitals where I know this plan was in operation for some time, I find they have given it up. I do not know exactly for what reason, but it appears that they did not find it answer so well as they expected.

There is one form of prepared food I may refer to which is very important, namely, what is known as Pemmican, a substance greatly used amongst all Arctic voyagers for many years. It consists simply of well selected meat carefully cooked and dried, pounded up and mixed with a large quantity of fat and a small amount of spice. This substance, from the way in which it is prepared, will remain for a long time without undergoing any change whatever, and it is extremely nutritive. It contains no less than 35 per cent. of albuminates, and over 50 per cent. of fat. This substance is pleasant to taste, it is easily made into soup or otherwise used; but its prolonged use, unless with the addition of vegetable

food or lime juice, is certainly productive of bad results. We had that shown in the last Arctic Expedition, where the boat expeditions went away with a supply of this article but without any anti-scorbutic food, and the necessary result was that in a very short time the men suffered from scorbutic diarrhœa and were totally unable to swallow the proper amount of food.

But amongst the Hudson's Bay hunters and others who have been engaged in the Arctic regions a considerable time, this substance has been very largely used, either alone, or, as is sometimes the case, mixed with raisins and currants, which would give it a certain amount of anti-scorbutic property. But in all cases where this limited form of diet is in use, the persons using it take every opportunity of obtaining vegetable food in some form or another to assist the proper digestion of it; all sorts of Arctic berries, and even sometimes plants of different kinds; the partially masticated contents of the stomach of the reindeer also are greedily eaten by the Esquimaux, just as the contents of the stomach of the cow or bullock are eaten by the Caffres in South Africa, under conditions where vegetable food cannot be obtained.

Other forms of preserved food consist of the familiar forms of jam and other modes of preserving vegetable food, which all have their special use. I may mention one method of preservation which is being lately tried, and that is a way of preserving butter, when it is plentiful in summer and does not find an immediate market, for use in winter when it is expensive and difficult to get. We all know that there is a considerable difficulty in getting a sufficient amount of fat in our diet, and in consequence of the high price of butter there have been introduced a great many substances known as butterine, oleo-margarine, and the like, which rumour says are often derived from very unsavoury sources. People have even gone so far as to say that the scum from the surface of the Thames, at the Barking and Crossness outfalls, is skimmed and the fat melted out, which is converted into butterine. I do not think that is practi-

cally the case; there are other uses for fat of this description, but certainly we had before the Royal Commission on Metropolitan Sewage Discharge one or two individuals whose sole occupation in life consisted in skimming this greasy like substance from the surface of the Thames, rendering it, and selling it; but they would not commit themselves to where it went, or what use was made of it. Of course there is no reason why such substances as butterine and imitation butter should not be perfectly wholesome if made of fat obtained from proper sources. But the method of preserving butter I was referring to is a plan which has been but lately introduced, by keeping the butter in a cool dry chamber, hermetically sealed from the external air. And at Berkeley Castle, Lord Fitzhardinge, who takes a great interest in dairy farming, has constructed an arrangement of this sort, and the experiment is going to be tried this summer, I hope with success, because it will perhaps to some extent cheapen the price of butter, which has become so high, especially in the winter. The importance of having a considerable amount of fat is very great for the community generally. It was even said, forty or fifty years ago, by a very wise and eminent physician, that one of the causes of the great prevalence of consumption in this country was the high price of butter; and I believe that although this was a very sweeping statement, it certainly was not untrue. If we could get a larger amount of fat introduced into the diet of the people it would be highly beneficial, and we know that in the case of consumptive patients great benefits are derived from the taking of cod liver oil or other similar fats.

I am afraid I have now reached the end of my time, and I have only to thank you for your kind attention.

The CHAIRMAN: Ladies and gentlemen, I am sure you will join with me in returning a vote of thanks to Professor de Chaumont for his excellent lecture. He has shown you that the body is a machine, and that there are two functions in the body with regard to nutrition. There is the continual waste of the parts of the machine, and that

has to be made up with materials fit for its structural parts, that are called the albuminates. They are exactly of the same composition as the flesh and blood of an animal. If you take the cheese out of milk, or if you take the cheese out of beans and peas, for beans and peas contain about 20 per cent. of cheese, and the Chinese make cheese out of them; or if you take it by stirring the blood of an animal, or if you take it by stirring the juice of a cauliflower or cabbage, and you put these dried substances into a chemist's hands, with the dried flesh or dried blood of any animal, the chemist is unable with all his refinements and all the delicacy of his balance, to find the slightest difference between them. These substances have to be built into the body; they are already the composition of the body. It is the duty of plants out of the aerial food around them, to mould them into the forms of flesh and blood. The animals have only to give them a position in their organisms. They are not troubled with making the materials, and therefore the building up of the machine from these albuminates is simply the placing them in position to replace the wasted parts of the machine. I am quite sure that if I were to ask nine tenths of you how long a body takes to waste—how long the machine that we have to build up, which is continually going on, some parts of it, such as the heart, from our birth to our death without the slightest cessation of work, will take to waste—you would answer me according to the old statement, which you believe as firmly as any creed of any church, that the body changes in seven years. Now the soft parts of the body, the muscles and so on, change every six weeks, or nearly that time. The waste, as indicated by the waste matter that goes away from the body, represents an amount that in about six or seven weeks amounts to the whole weight, so that in that time we must restore it entirely. Therefore it is of extreme importance, as Dr. de Chaumont has shown you, that we should put in as much as is wasted. About four ounces a day of flesh-formers must be used to keep a man in health, in ordinary active work; it is not

enough for a labourer. If a man is doing very hard work he requires about an ounce more, or five ounces. But sometimes, from ignorance of this, the most miserable effects on nutrition have been produced. There is an incessant change of particles in our body. I cannot raise my hand without the muscles which I use being wasted, and it is the duty of nutrition to restore those wasted parts. There is incessant death and incessant life going on in every part of the body. Every particle of the body is dying according as it is used, and every particle is born again by being built in and becoming a new part of life. Therefore you see the importance of knowing the constituents of food, and showing how different materials should be used under different circumstances; some years ago, for instance, I had the melancholy duty of being a commissioner on the Irish famine; and where there was very little money it was very desirable to feed the largest number of persons with a small amount of money; and a knowledge of food became of infinite importance on such an occasion.

For instance, supposing I have the duty to put a pound of flesh on a man in a day, or series of days; for he only requires four ounces a day, and he would require four days to get a pound; and if it was my duty to put a pound of flesh on a man, it would cost me 1*s.* 8*d.* to 2*s.* to do that out of flesh; 1*s.* 4*d.* to do it out of potatoes: but in the shape of peas I could do it for 3*d.* Now I will come to my practical conclusion. When you go through the Exhibition you will find in the Central Hall, half way down, all the foods analysed or split into their constituent parts, according to pound weights of each. It comes to no more information than is on this table on the wall, but it is in a convenient form. You will see of each food one pound contains so much water; so much flesh-formers, or albuminates; so much heat-givers, because you have to give fuel to the machine to keep up the heat; so much mineral matter to form bone; and you will find every food there split up into its constituent parts of a pound; and it is a very instructive set of cases but I am afraid it is passed

over without being looked at so much as the more attractive things. However, I find I am giving a lecture instead of moving a vote of thanks, which is what I rose for the purpose of doing, and which I now do.

The vote of thanks was carried unanimously.

Mr. A. J. R. TRENDELL then moved a vote of thanks to Sir Lyon Playfair for his kindness in coming to act as Chairman in the midst of absorbing parliamentary and professional duties. He felt sure that the meeting would appreciate the very practical remarks the Chairman had made, and begged to thank him on behalf of the Executive Council for presiding. The resolution was carried unanimously.

THE CHEMISTRY OF BREAD-MAKING.

BY

PROFESSOR CHARLES GRAHAM, D.Sc., F.I.C.
(UNIVERSITY COLLEGE, W.C.)

JULY 3RD, 1884.

A LECTURE ON THE CHEMISTRY OF BREAD-MAKING.

By PROF. CHARLES GRAHAM, D.Sc., F.I.C.

THE chair was taken by Prof. ODLING, F.R.S., who, in introducing the lecturer, said he hoped it would not be considered presumptuous in him to suggest that the Executive Council of the Exhibition had done well both in their selection of the subject and the lecturer. When primitive man ceased to be exclusively a hunter he became next a shepherd and a herdsman, and the next stage in the advancement of civilisation he became a husbandman; how soon after becoming a husbandman he became a bread-maker and a baker, he did not think the earliest prehistoric records would exactly tell, but, at any rate, he thought they might fairly look back upon bread-making as probably the earliest, or at least one of the earliest, chemical arts; one which had existed for a great many thousand years. Perhaps, he could not say, that during all those thousand years it had made such a rapid rate of progress as some of the more modern chemical arts; nevertheless, the art of bread-making still retained a very large amount of interest, and bread might still be regarded as the staff of life. He would only add that Prof. Charles Graham was one of the leading authorities in the particular department of chemistry which related to the study of those changes called fermentative, one of the most important of which was the process which was called panification, or the chemical art of transforming flour into bread.

LECTURE.

Our distinguished Chairman, Prof. Odling, the President of the Institute of Chemistry, in introducing me to you has been so good as to refer to my position in regard to fermentation chemistry, and I presume that it was in reference to this that the Council of the International Health Exhibition requested that I should give a lecture on a subject of vast importance to us all. I consented to do what I could in this matter; other men of science are also engaged aiding the Council of this Exhibition, not only in the awarding of prizes among the various exhibitors, but in aiding in the selection of the materials to be sent here, and also in assisting at conferences and lectures on various matters pertaining to the great object of this Exhibition, namely, Health.

The cereals are undoubtedly the most valuable of all the fruits of the earth, and it is, therefore, needful that we should rightly study their mode of preparation for the use of man. The question may have occurred to some of you, how can science aid art? Surely a good baker requires no assistance from science. Let us see what is the answer to it. Without going through a number of instances in which undoubtedly science has advantaged art, I will refer only to one or two. In the first place, there is no doubt that agriculture has benefited largely by the investigations of Liebig, and, following him, of others, into the composition of the mineral matter of plant life. It is perfectly true that in metallurgy, steel was obtained ages ago of the very highest excellence. Yet surely the study of chemistry has enabled us to manufacture iron and steel at such a price and in such quantities as would have been utterly impossible in the olden time. Again, take another illustration, that of dyeing; there are two methods of dyeing of great historic interest—that of Turkey red dyeing and that of indigo dyeing—because these are the only two really permanent colours, and secondly because science has investigated the nature of Turkey red dyeing, and has found

out that the important principle in the madder root was alizarine. Science has not stopped at merely finding out the nature of the dye; science has succeeded in creating the dye out of gas-tar products. Lately, indigo has in a similar way been created, it is already a success, and will soon become a great commercial success. I give those merely as illustrations of the way in which science can benefit art, and though we need not look for any such startling, such epoch-making discoveries as that of the making and building up alizarine and indigo, still I feel sure that science little by little will greatly improve the art of bread-making.

I have the honour of addressing some London bakers, and there are London bakers who are exhibitors in this Exhibition, and it is perfectly true that we now get in London bread of the highest excellence, but still the Council of this Exhibition are not thinking only of the best West-end bakers, they are not limiting their views solely to London bakers,—they are considering the interests of the United Kingdom, and, indeed, of other countries, and one of the arrangements I understand in regard to these lectures is that they shall be published in a very cheap form, so that in this way one's audience may be larger than that in this room. I had proposed to make a few remarks in regard to the history of bread-making, but after the introductory remarks of our Chairman I think I need do no more than briefly enumerate the three distinct stages. First; flour was mixed with water, baked, and then eaten; the next great improvement was the discovery of leaven; both of these are very old methods for the treatment of flour and known to the ancients; and at the present day we have examples of both systems; we have bread without any ferment at all, as in parts of Spain, and we have also leaven bread in the North of Europe, but the next great and important improvement was the use of yeast. This has occurred in more modern times, how many hundred years ago I know not, but still comparatively modern as compared with the older methods.

Before studying the phenomena of bread-making, it will be necessary to study the composition of the cereals employed in bread-making. In the corner of the room there is a Table taken from papers published by Messrs. Lawes and Gilbert, giving us the composition of wheat, barley, oats, rye, maize, and rice.

AVERAGE COMPOSITION OF THE GRAIN OF CEREALS.

	Old Wheat.	Barley.	Oats.	Rye.	Maize.	Rice.
Water	11·1	12·0	14·2	14·3	11·5	10·8
Starch	62·3	52·7	56·1	54·9	54·8	78·8
Fat.	1·2	2·6	4.6	2·0	4·7	0·1
Cellulose . . .	8·3	11·5	1·0	6·4	14·9	0·2
Gum and Sugar .	3·8	4·2	5.7	11·3	2·9	1·6
Albuminoids . .	10·9	13·2	16·0	8·8	8·9	7·2
Ash	1·6	2·8	2·2	1·8	1·6	0·9
Loss, &c. . . .	0·8	1·0	0·2	0·5	0.7	0·4
Total . .	100·0	100·0	100·0	100·0	100·0	100·0

COMPOSITION OF WHEAT GRAIN ASH.

	Lawes and Gilbert.	Way and Ogston.
Phosphoric acid. . . .	49·68	45·01
Phosphate of iron . . .	2·36	0·82
Potash	29·35	31·44
Soda	1·12	2·71
Magnesia	10·70	12·36
Lime	3·40	3·52
Sulphuric acid	..	0·34
Carbonic acid	..	0·02
Chlorine	0·13	0·13
Silica, &c.	2·47	3·67
Total. . . .	99·21	100·02

I wish to draw your attention to some important points connected with those analyses. We may divide the constituents of the cereals of wheat, for example, into the mineral matter and the matter which is not mineral, and to which we give the term organic matter. The mineral matter consists of phosphate of potash, and of magnesia,

about one-half being phosphoric acid, one-third potash, and one-tenth magnesia. The organic constituents consist of what are termed carbo-hydrates, together with a small quantity of fat. I say carbo-hydrates, an expression used to indicate that in these kind of bodies the carbon, the hydrogen, and the oxygen are united together to form the substance, starch for example, and that the hydrogen and oxygen are in the same proportion as in water, though they are not combined together as in water, and therefore, the expression carbo-hydrates is given to such bodies. These carbo-hydrates are the substances that yield heat to the body, and by so doing yield force, power. In addition to these we have the substances termed albuminoids. These are also spoken of as flesh-formers. Now, it is perfectly true that this expression correctly describes the function they perform, namely, to repair the waste of the muscular tissue, but at the same time it is somewhat misleading in that these flesh-formers are really mainly used up in giving heat and force by their burning or oxidation in the body, only a comparatively small quantity being necessary for the waste of the muscular tissues, which is by no means so great as physiologists formerly assumed.

Starch occurs stored up in vegetable structures for much the same reason as fat occurs stored up in animal structures, namely, for future use, thus we find starch in bulbs, and in tubers. It is the starch-yielding property of the potato which renders it chiefly valuable. We find it also in roots, such as turnips, and the beet-root; we find it of course in seeds, and lastly we find it in the thick leaves termed by botanists cotyledons, the two thick leaves which in leguminous plants such as the bean and the pea form the larger part of the seeds. The whole of the matter inside the testa or skin of the bean really consists of the two thick young cotyledon-leaves, thus we have various sources of starch. Starch, however obtained, will be found, when examined under a microscope, with a proper measuring arrangement, to have different characteristic appearances, and also sizes. For example, the starch of wheat varies

much from that of barley, and very much from rice. It is by the size, which can be accurately measured, and by the form or shape which we can note under the microscope, that we are enabled to identify various kinds of starches. Starch, as you know, does not dissolve in cold water, and indeed water is used in the extraction of the starch after grinding the grain, or rasping the potato from which we are deriving the starch. But when to a mixture of cold water and wheat-starch a laundress pours boiling water, she raises the temperature, and the result is that the starch-cell bursts. The outside of the cell is composed of woody fibre, and at this higher temperature it bursts, the internal contents of the starch-cell then come out. To those contents we give the term granulose, which makes a paste with the hot water. This is an important point in regard to the digestion of starch. At a temperature of about 300° F. starch is converted into dextrine or British gum. If, however, instead of employing that plan you add, to a thick starch paste a little ground malt, the ground malt will convert the starch paste into dextrine together with another product which I will refer to presently. But the dextrine formed in that way is not pure. A still better plan is to make a mixture of 1000 parts of starch with 300 of water, to which previously two parts of nitric acid have been added; you mix the two together, and this is afterwards air-dried, and when it is revolved in a cylinder at the temperature of not higher than 220° to 230°, it is converted into dextrine, and it is in that way that the dextrine of commerce is now manufactured. You are all acquainted with the appearance of it, because you have all of you seen the 1*d.* or 2*d.* bottles of British gum, and it is on the back of every postage stamp, and it is used very largely in the arts, in calico-printing for example. Closely allied to starch and dextrine comes cane-sugar and maltose-sugar. Cane-sugar, you know, is derived from the cane-plant, from the beet, or from the maple, its properties you are sufficiently well acquainted with, namely, that it is sweet, and dissolves in water and crystallizes easily. Maltose *sugar* is what I was referring to just now when I said that

on the addition of a little malt to starch paste there was another product formed besides dextrine, and that other product is maltose, having the same centessimal composition as cane-sugar. Maltose sugar was discovered by Debrunfaut, and was afterwards the subject of experiment and study by Musculus, but it was not until comparatively recently, owing to the researches of Mr. O'Sullivan, of Burton-upon-Trent, that we really understood the nature of the change that took place by the action of these albuminoid bodies, such as we find in malt upon starch paste. He showed us that a starch solution is acted upon by the diastase, as it is called, of the malt, and that it takes up water and forms maltose sugar and dextrine, the maltose sugar having the same formula as cane-sugar. This process continues, and more maltose is formed by the action of the diastase upon the more complex dextrines which are formed at first. Ultimately, however, a large portion of maltose is formed, and a very small quantity of dextrine, and under the most favourable conditions it is possible to convert the whole of the starch into maltose sugar. The maltose sugar thus made, dissolves in water, it is slightly sweet to the taste, and it does not crystallise in the way that cane-sugar does, and it is much more difficult to obtain in a crystalline form. Maltose sugar is readily acted on by the yeast ferment.

The next matter of interest in the study of these bodies are the albuminoids; the albuminoids contain carbon, hydrogen, and oxygen just in the same way, but not in the same proportion as the carbo-hydrates, but they have in addition nitrogen, and sometimes a little sulphur. Their general composition is given in this table:—

Average Composition of Albuminoids.

Carbon	53·3
Hydrogen	7·1
Nitrogen	15·7
Oxygen	22·1
Sulphur	1·8
	100

Hypothetical formula, $C^{72}\ H^{112}\ N^{18}\ SO^{22}$.

If we take the formula of starch as being C_{72}, H_{120}, O_{60}, you may not see any relationship between that and the albuminoids, but yet the probabilities are that the starch is only an altered form of the albuminoid, and that it has previously gone through such an albuminous stage. In the Table, by Lawes and Gilbert, you will find that the albuminoids are given there for different cereals. At the same time, as we shall see presently, cereals differ very much in the percentage of albuminoids they contain, and in the Table the placing of 10·9 of albuminoids to old wheat was perfectly correct for the sample of wheat analysed, but it leads one to assume that wheat is less rich in albuminoids than barley and oats, but it is distinctly on the average not less rich, but rather more so than barley. If we take ordinary flour, and then elutriate it with water so as to get rid of the starch, we shall ultimately obtain crude gluten. The crude gluten, of which we have some samples on the table, is a tough elastic mass, and it is on account of this great resisting tendency that we are enabled to keep in the carbonic acid that is subsequently formed in fermentation, and thus to make a well-piled loaf. Now crude gluten contains fibrine and gluten; about four-fifths of fibrine and one-fifth of gluten; the gluten is slightly soluble in water, but not the fibrine. Of course, if fibrine be moistened and left for a time it will gradually break down in the complexity of its structure, and will form simpler kinds of albuminoids, and this is the kind of deleterious action that takes place when we have a long-continued period of wet weather at harvest time. But while washing the flour in order to obtain this crude gluten, we have already dissolved out some soluble albuminoids.

Now these soluble albuminoids occur to a small extent in wheat, even the best elaborated; but they occur to a much larger extent in other kinds of cereals, as barley for example. Of these, albumin and legumin, so called from the legumenosœ in which it is abundantly found, differ mainly in this respect, that the albumin can be coagulated *by boiling*, whereas the legumin cannot. In addition to the albumin and legumin, we have also another albuminoid

substance called cerealine. Now it is the cerealine which is found so largely in the bran of wheat, and not to the same extent in barley. If we take what is termed, botanically, the caryopsis, or the seed, of barley, and moisten it and keep it at a proper temperature in a warm room it will gradually grow, and, as it grows, rootlets will come out from the bottom, while the plumule pushes up inside the testa or skin; as it does so, this plumule, which is growing up inside the testa, gradually by an osmotic action from cell to cell sets up a diastasic change throughout the whole of the berry, so at last, as it grows up and ultimately gives off a stem and leaf, it has greatly affected the starch granules inside the seed. Now, in the case of wheat, the little embryo at the bottom pushes out its root, but at the same time the plumule comes out also, thus the plumule has no diastasic action, except by osmotic action through the cells at the base. Nature, however, partly gets over this difficulty by the diastasic action set up by the albuminoid cells in the cerealine acting throughout the whole mass, so that sugars are formed for the nourishment of the young growing plant. This is the important function of the cerealine in the bran of wheat. Now, barley has got but little gluten, the albuminoids are not of that character, they are not dense and coherent, and rye-flour, maize and rice are all equally deficient, and the consequence is that for the preparation of fermented bread there is no cereal that can compare with wheat.

I will ask you now to look at some results obtained by the chemist Péligot. In this Table you will find the composition of different typical wheats—Flemish, Odessa, Herisson, Provence, Midi, Polish, Hungarian, Egyptian, Spanish, and Russian. In this Table we have the albuminoids divided into those which are insoluble and those which are soluble. This method of stating the results is of very great importance to the baker. If you look at this Table you will find, by dividing the insoluble albuminoids by the soluble, that we have in the Flemish a ratio of 3½ of the insoluble to 1 of soluble; in the Odessa,

8 of insoluble to one of soluble; in the Midi, 9 to 1; in the Egyptian, 13 to 1; and in the Spanish, 5 to 1.

ANALYSES OF WHEAT (PÉLIGOT).

	Flemish.	Provence.	Odessa.	Hérisson.	Poulard Roux.	Poulard Bleu.	Poulard Bleu. Dry year.	Midi.	Polish.	Hungarian.	Egyptian.	Spanish.	Taganrogg.
Water	14·6	14·6	15·2	13·2	13·9	14·4	13·2	13·6	13·2	14·5	13·5	15·2	14·8
Fat	1·0	1·3	1·5	1·2	1·0	1·0	1·2	1·1	1·5	1·1	1·1	1·8	1·9
Insoluble Albuminoids	8·3	8·1	12·7	10·0	8·7	13·8	16·7	14·4	19·8	11·8	19·1	8·9	12·2
Soluble Albuminoids	2·4	1·8	1·6	1·7	1·9	1·8	1·4	1·6	1 7	1·6	1·5	1·8	1·4
Dextrine	9·2	8·1	6·3	6·8	7·8	7·2	5·9	6·4	6·8	5·4	6·0	7·3	7·9
Starch	62·7	66·1	61·3	67·1	66·7	59·9	59·7	59·8	55·1	65·6	59·8	63·6	57·9
Cellulose	1·8	..	..	..	..	1·5	..	1·4	..	..	..	..	2·3
Saline Matter	..	..	1·4	..	..	1·9	1·9	1·7	1·9	..	..	1·4	1·6

I only give those as being illustrative of the very great variety that occurs in different cereals. A very interesting point to notice in the Table of determinations made long ago by Péligot is this, you will find that if you divide the dextrine, as he termed it, by the soluble albuminoids, you will, with the exception of one or two, that it is nearly four times as much as the soluble albuminoids; in many cases it is exactly. In the Midi it is 1·6 soluble albuminoids to 6·4 dextrine, which is exactly 1 to 4. I can see in the next one, the Polish, it is 1·7 of soluble albuminoids to 6·8 dextrine, showing that there must be some very distinct relation between the amount of dextrine formed and the albuminoid body that has gone to form it. That is an interesting point for chemists.

It is of the highest importance for the milling interest, and also for the baking interest, that a very large and numerous series of analyses, made even with further determinations than were possible at the time of Péligot, should be made in order to guide the miller in his selection of wheats for the different kinds of flour. I have now to call your attention to a diagram headed "The Influence of Seasons on Wheats," and have marked certain years +, and have

marked some other years –, and there are one or two years marked with a slanting mark. Now, if we take those years against which I have attached +, 1846, 1849, and 1851, we learn that those years were dry years of fine harvest weather, and the result was that the total produce for those years was high. The amount of dressed corn in the total produce was also very high, and, in addition to that, the weight of corn per bushel, which is the farmer's

INFLUENCE OF SEASONS ON THE CHARACTER OF WHEAT CROPS. (LAWES AND GILBERT.)

Harvests.	Particulars of the Produce.				Composition of Grain.			Composition of Straw.		
	Total Corn and Straw per Acre in lbs.	Per cent. Corn in Total Produce.	Per cent. Dressed Corn in Total Corn.	Weight per bushel of Dressed Corn in lbs.	Per cent. Dry (212° F.).	Per cent. Ash in Dry.	Per cent. Nitrogen in Dry.	Per cent. Dry (212°).	Per cent. Ash in Dry.	Per cent. Nitrogen in Dry.
— 1845 . .	5,545	33·1	90·1	56·7	80·8	1·91	2·25	..	7·96	0·92
+ 1846 . .	4,114	43·1	93·2	63·1	84·3	1·96	2·15	..	6·02	0·67
1847 . .	5,221	36·4	93·6	62·0	..	..	2·30	..	5·56	0·73
— 1848 . .	4,517	36·7	89·0	58·5	80·3	2·02	2·39	..	7·24	0·78
+ 1849 . .	5,320	40·9	95·5	63·5	83·1	1·84	1·94	82·6	6·17	0·82
/ 1850 . .	5,496	33·6	94·3	60·9	84·4	1·99	2·15	84·4	5·88	0·87
+ 1851 . .	5,279	38·2	92·1	62·6	84·2	1·89	1·98	84·7	5·88	0·78
— 1852 . .	4,299	31·6	92·1	56·7	83·2	2·00	2·38	82·6	6·53	0·79
— 1853 . .	3,932	25·1	85·9	50·2	80·8	2·24	2·35	81·0	6·27	0·20
/ 1854 . .	6,803	35·8	95·6	61·4	84·9	1·93	2·14	83·7	5·08	0·69
Means .	5,053	35·4	92.1	59·6	82·9	1·98	2·20	83·2	6·17	0·82

way of determining the specific gravity of corn, was also very high. In 1846 it was 63, and that is a high weight for English wheat; on the other hand, if we take 1845, 1848, and 1852, against which I have placed –, we had wet summers, cold harvest weather, and the result unsatisfactory; such years as, indeed, we have experienced much more recently, and in these cold wet summers and autumns we obtained wheats with a low total amount of produce. The total dressed corn was low in 1848, being

only 89, whereas in 1846 it was 93, and in addition to that the specific gravity of the corn was also low; 56 in 1845, and 58 in 1848, instead of being, as I have said before, 63 in a good year. Then we have a high nitrogen; the amount of albuminoids was high, but the amount of resisting gluten was very low—in other words, those flours were ill-adapted for baking purposes. On this other Table, I have some experiments I made for the purpose of this lecture, in order to point out to you by experimental numbers the character of the changes which take place when flour and water are kept together at about a temperature of 85° F., which is the temperature that the baker employs. Vienna whites, allowed to stand only 10 minutes, give us ·76 of

INFUSION PRODUCTS OF FLOUR.

	Cold. 15 Mins.	2 Hrs.	4 Hrs.	8 Hrs.		Cold.	2 Hrs.	4 Hrs.	8 Hrs.
Vienna Whites.					Second Households. No. 1.				
Maltose	trace.	2·41	3·65	4·09		1·36	2·83	4·09	5·39
Dextrine	trace.	2·17	2·79	4·35		0·89	2·34	2·40	3·80
Soluble albuminoids	0·76	0·58	0·76	1·29		0·76	0·65	1·29	2·12
	0·76	5·16	7·20	9·73		3·01	5·82	7·78	11·31
Best Whites.					Second Households. No. 2.				
Maltose	none.	1·57	2·04	3·41		1·57	6·01	6·01	7·59
Dextrine	1·21	1·48	2·74	2·85		1·04	0·84	1·21	0·67
Soluble albuminoids	0·71	0·58	0·81	1·54		1·05	1·45	1·31	1·89
	1·92	3·63	5·59	7·80		3·66	8·30	8·53	10·15
Best Households.					Brown meal.				
Maltose	1·00	1·36	4·09	3·93		trace.	3·41	3·93	4·99
Dextrine	1·13	2·46	2·09	3·79		2·70	0·95	2·09	2·89
Soluble albuminoids	0·93	0·79	1·23	1·42		0·62	0·70	1·39	1·33
	3·06	4·61	7·41	9·14		3·32	5·06	7·41	9·21

			WITH LIME.		HIGH DRIED.	
Inferior Flour.	4 Hrs.	8 Hrs.	4 Hrs.	8 Hrs.	4 Hrs.	8 Hrs.
Maltose	6·82	11·14	6·82	8·20	4·44	4·44
Dextrine	0·43	1·28	0·11	2·15	1·78	2·91
Soluble albuminoids	3·19	3·74	3·34	3·34	2·48	3·29
	10·44	16·11	10·27	13·69	8·70	10·64

soluble products. In 2 hours, however, it is as high as 5·16, in 4 hours 7·2, and in 8 hours 9·73. In second households, we have in the cold 3·01; 2 hours, 5·82; 4 hours, 7·78; in 8 hours, 11·31. Now, in No. 2 we have also in 8 hours 10·15—the brown meal being very much of the same general character as that of No. 2. A small Table shows the results of a distinctly soft flour, in which in 4 hours the amount of soluble matter was 10·49, in 8 hours 16·11. When, however, that flour was treated by a method investigated by our distinguished Chairman in 1858, with lime (only in this particular instance I simply used a little chalk instead of quicklime), we had a considerable reduction at the end of eight hours; and that is the important point, because the process of the London baking requires a great many hours, and therefore it is desirable to see what influence hard water, such as one would get in Kent, or made so artificially, would be. You will see that we are enabled to lower somewhat the amount of soluble albuminoids. That same flour, when heated to a temperature of 100° for several hours, as in the kiln-drying process, gave still better results, and at the end of eight hours the amount of soluble products was reduced from 16 down to 10·6, showing therefore that the heat-stiffening action of the kiln is of the very greatest importance indeed in improving the character of our inferior wheats, due, perhaps, to inferior harvest conditions.

I proceed now to the subject of milling. I am not a miller, and I have not sufficient time, even if I had sufficient knowledge, to entertain you with a discussion as to the respective merits of high and low reduction, of rollers *versus* stones. The City and Guilds Institute of London a few years ago established examinations in the chemistry of bread-making, and, due chiefly to the active aid of Mr. Dunham, the proprietor of the *Miller* newspaper, and also aided by active millers taking a keen interest in their trade, they have recently added milling to their curriculum of examination. You are probably most

of you aware that the City and Guilds Institute carry on in technology much the same kind of examinations, although I hope better in character, as the Science and Art Department do throughout England, Scotland, and Ireland in their May Science Examinations. Milling has been given to those interested in milling, and in looking over the character of the questions set I am bound to say that in a very short time it must stimulate the young millers to study, not merely the chemistry of their art, but to study the engineering part of their profession in a way that has not been hitherto done in our country, and therefore I think that the City and Guilds Institute will do considerable good in this direction.

As a chemist, however, and as I am lecturing upon the best means of preparing wheat bread fit to compare with the beautiful bread of Moscow or Paris, I think the following conditions are essential to be aimed at in good milling. In the first place, the corn must be degerminated, because the germ is an active hydrating and diastasic body; secondly, the bran must be thoroughly eliminated, because the cerealine of the bran has this injurious action on the fermentation, that it produces too great a quantity of maltose sugar and dextrine, and introduces also too large a quantity of soluble albuminoids into the bread, which soluble albuminoid, not the starch, as some people imagine, give high colour in the oven. Degermination and elimination of the bran are, I hold, tests of the highest milling, whether it be by rollers or by stones. For brown bread and for whole-meal bread there is a difference, and I will later on point out how we may to some extent eliminate or obviate the difficulties when we employ brown flour or whole-meal flour. A very important point is the admixture of wheats; formerly millers were obliged to use the wheats as they could find them in their own country, but now we have excellent wheats from the United States, from Canada, from the Black Sea, from Australia, and lastly, and not of the least interest, from India and Persia. I read a statement in a newspaper yesterday that the

Indian Government had been making an investigation into the question of the expense of growing wheat in India, and they find the natives can grow wheat for 12*s.* a quarter—16*s.* will leave a profit. Some objection has been made to the employment of too large a quantity of Indian wheats when mixed with our own, owing, it is said, although I have not noticed it myself, to the aromatic flavour of bread that has had too large a proportion of Indian wheat ground with our English or other wheats. This is, however, a matter that the miller can readily obviate by a little attention to the admixture, and by not using perhaps quite so much of the Indian wheats. At the present moment we are able to get excellent wheats as low as 32*s.* per quarter. Now I remember at a dinner, I think it was in 1872, the motto of the Royal Agricultural Society of England was given as a toast after dinner, that motto being "Practice with Science;" and I was associated, being a scientific man, with a practical farmer in replying to that toast. In my reply I referred to some of the advantages of science; but then, speaking to British farmers, I pointed out some of the disadvantages of science; I pointed out how by using both high and low pressure steam on board ship, as Elder was beginning to do, with the development of the railway carrying powers of America, the United States farmer would in a very few years be able to sell wheat at a profit at 40*s.* per quarter at Liverpool, not only were they very incredulous, but they laughed at me; but to-day you can get it at 32*s.* per quarter, and this is not entirely due to the great activity of the Americans in growing wheat; the fact is, that the great wheat speculators in America were not aware of the enormous amount of wheat that India can send to us. This great speculation in wheat, what they call the "wheat ring," has broken down completely, and we are now able, thanks chiefly to India, to have wheat at this very low price. It is an additional satisfaction to an Englishman that South Australia, New Zealand, and also India, have a large wheat-growing capacity, because in India free trade is the rule, whereas the Americans are

protectionists, and by our purchasing large quantities of wheat from India, we may expect, of course, that they will take large quantities of our manufactured products, hardware and cotton, from us in exchange, so that in that way from our colonies and from India we shall not only have cheap wheat, cheap flour for some time to come, but also have the prospect of a better condition of our manufacturing industries.

The miller's method of testing wheats consists in judging by their appearance, by the weight per bushel, by the country in which it is grown, and lastly by grinding, by baking some. A distinguished baker in Paris, M. Bolland, adopted a method by which he separated the gluten from the flour, and this gluten was put into a tube, and the tube put into the oven, and according to the amount of expansion of the gluten, so did he decide upon the quantity of the gluten there, and its resisting action to steam—in other words, he judged in that way of the goodness of the flour for the fermenting process of making bread.

The plan which I suggested some time ago was this, that 1 oz. of flour should be mixed with 4 ozs. of water, and allowed to stand at the temperature of about 80° or 85° for two hours; that it should then be filtered, the first portion of the filtrate will be a little thick, but the latter portion will not be so thick. You put this into a test tube, which you have previously marked at 1 oz. and 2 ozs.; it is filled up to 1 oz., and then is mixed with 1 oz. of strong methylated alcohol, which we can get for about 5*s.* a gallon; the result is this, that you obtain a precipitation of most of the soluble matters, of maltose, of dextrine, and the soluble albuminoids; and according to the amount of precipitation, so you would decide as to the amount of soluble matter that would be produced during the sponge stage of bread-making.

I proceed now to consider the question of bread-making. The ways of making bread are very numerous in different parts of the country. I will therefore limit myself solely to the London system of bread-making, which is one of the

best. The London system consists of three parts—the preparation of the ferment, the preparation of the sponge, and the preparation of the dough. A sack of flour is 280 lbs. in weight, and it should yield from 94 to 96 quartern loaves. In the preparation of the ferment, 6 lbs. to 8 lbs., sometimes as much as 12 lbs., of the very best potatoes are employed; inferior potatoes will not do. These are thoroughly cleaned, washed, cut up and boiled, and then when made into a thin paste they are poured into a tub, and cold water added until the temperature is lowered to 85°. When this is done, about 2 lbs. of flour are added, and then one quart of good brewers' yeast stirred in; this is the preparation of the "ferment;" fermentation begins, the yeast acts upon the albuminoids of the wheat, and the albuminoids of the wheat so acted upon act then upon the starch of the boiled potato, and the result is we have maltose sugar, and dextrine, and peptone bodies formed. After five hours, the time depending on the temperature, the head falls and then the ferment is allowed to rest for about two hours. The baker then proceeds to the next stage, which is the preparation of the sponge or "stirring the sponge." In making the sponge one-fourth, or according to some bakers one-third, of the flour is taken, placed in the trough, the ferment added through a sieve which retains the potato-skins, the water in the ferment and sponge being about thirty quarts; bear in mind I am always speaking of the sack of 280 lbs. of flour. The quantity of water, however, varies slightly with the kind of flour and slightly with the baker's own particular practice. The other ingredient is salt. Now many London bakers do not use salt in the sponge stage, nor is it needful in the very highest classes of flour; others, however, prefer to use some of the salt, and the quantity of salt therefore used in this stage varies. The amount altogether used for a sack of flour is 3 lbs., or 48 ozs., that is $\frac{1}{2}$ oz. for each quartern loaf. Now, salt acts as a check upon fermentation. The more salt you add to the sponge stage the more you check the degradation or break-

ing up of the albuminoids. The sponge being made ferments, and in about five hours it breaks, carbonic acid being given off, and in an hour it rises again and again breaks. This last will depend on the temperature. After the second break, the remainder of the flour, be it three-fourths or two-thirds, according to the practice of the baker, and the remaining portion of the water, is added; the total quantity of water for the whole sack is 60 quarts. These are thoroughly mixed together, and in the dough stage many bakers, as I said, add the whole of the salt. Those, of course, who have used part of the salt in the sponge stage simply add the remainder. Of late years machinery has been invented to do away with the manual labour and other objections to the mixing of the dough; it is very hard work, and I should be glad for those of you who have time to look not only at the very useful mixing machine of Mr. Pfleidèrer, but also to look at the mixing machine of Melvin, of Glasgow, in Mr. Marshall's model bakery, which consists of a number of revolving cutters which mix up the dough. The dough well mixed is then left for an hour, it rises, it is then scaled, that is to say, weighed and put in the oven, where it remains for one hour and a half, the atmosphere of the oven being about 400° to 450°. The temperature of the bread, I need hardly say, is not 400°, but much less, appreciably not more than 212°, but it may be a little over, owing to the resisting action of the crust, but at that temperature you know water boils, and therefore the temperature could not be higher. Before I pass on to a description of the scientific phenomena underlying these processes, I will briefly refer to the manufacture of fancy bread. Bakers, of course, differ in their manufacture of fancy bread in the same way as they do with ordinary household bread, but the following will give you an idea of the general method. In the first place a "ferment" is prepared as before, that is to say boiled potato with a small quantity of flour, and with brewer's yeast. Having prepared the ferment; in the sponge state, the baker uses a large quantity of German

yeast, and in this way he gets a very rapid fermentation and a large, light, porous bread. In regard to the chemistry of these operations, the fruit, that is to say, the boiled potato, yields ferment food, and thereby, by the action of the yeast on the soluble albuminoids of the flour, gives a rapid formation of maltose and dextrine. In 8 lbs. of potatoes there are only 2 lbs. of starch, so manifestly the baker does not use this small quantity for the sake of cheapness. It is because it is one of the largest of all starches, and therefore it is one of the best means of preparing albuminoid and sugar food for the active stimulus of yeast growth. The ferment stage increases the production of these albuminoids and sugars, and the yeast is in this way greatly stimulated; but another object that I ought to mention that the London baker has in making this preparation of the ferment is that he largely increases the amount of yeast. This method of feeding yeast during this number of hours, is a method of making a considerable amount of yeast out of the one quart that he takes. In the sponge state we have a very active fermentation going on; the sugar there is broken up into carbonic acid and alcohol, and there is a rapid action; and it is in this particular stage which lasts so many hours that inferior flours turn out so badly, because they produce more and more soluble albuminoids, and these give a high colour to the final product. In the dough state, which is practically the inert stage, because in the dough stage we have added all the flour, and only thirty more quarts of water; we have also a less period of time allowed, only one hour, and the result is that very little further change goes on. If the flour has withstood the sponge stage without injurious result, it will perfectly well stand the dough stage. The objects aimed at by the baker being to obtain good aëration, numerous small cavities of gas, in other words to give a well-piled loaf, also to avoid colour, because colour always gives rise to a suspicion of inferiority of the flour; and lastly, the baker's aim is to obtain a nice aroma, a fine

nutty taste, such as indeed cannot be got by any other method than that which I have been describing.

Fermentation is a subject that has been a source of considerable interest and speculation. I need not, however, do more than simply call your attention to our present knowedge on the subject, for which we are mainly indebted to Pasteur, in that it was he who first of all pointed out most clearly that it was due to minute organisms that fermentation was brought about. M. Pasteur proved that by withdrawing the internal contents of the grape that those contents would not spontaneously ferment, but that if you took a little cotton wool, and rubbed the outside of the skin and added that to that which was withdrawn, the fermentation was set up. We are all now of the same mind that fermentation is brought about by the action of living organisms, saccharomyces. The fermentation of the must of grape, which is the term for the expressed juice of the grape, which is brought about spontaneously, is not the only instance of spontaneous fermentation. Leaven bread, which I have spoken of, originally arises in this way, and is to some extent the result of spontaneous fermentation. The production of the old sour beers of Dorsetshire, the production of Lambick, or Faro, is of the same nature. Only the other day I had occasion in this Exhibition to taste a sample of Lambick beer, which is made by taking the wort of malt and leaving it to receive whatever dust falls into the large vat, and in the course of one year or two years the product, which they call Lambick or Faro, is obtained, which is excessively sour, because all kinds of ferments have brought about the change, not merely the alcoholic ferment. The yeast organism is one of considerable interest, and I have a diagram of the indications of the English country yeast, and Burton yeast, and there is also a drawing to represent the acetic acid organism, the lactic organism, and the organism which produces butyric acid, and also the organism which produces the ropy fermentation, the mannite and gum, instead of alcohol and carbonic acid. The

yeast organism under a good microscope will be found to have a cell wall. You will find inside a space, such as I have indicated, which is termed the vacuole, it is not really a vacuous space, but is filled up with a very thin protoplasm, or, as Professor Huxley calls it, the physical basis of life. The other portion is also filled up with protoplasm. Yeast contains a little granulated protoplasm. When it has been kept a long time it gets exhausted, and part of the albuminoid compounds or protoplasmic matter gets converted into other bodies, and they ooze out, and the result is that in looking through a microscope at the organism, instead of having to look at a well-filled cell, we have a thinner cell to look through, and the result is that the granulated protoplasm is seen much more distinctly. I have, therefore, given a rough representation of old yeast, or yeast that is exhausted. The conditions necessary for active yeast growth are that we should supply broken-down albuminoids and peptones for its nourishment, a certain quantity of phosphate of potash, lime, magnesia, together with a little air.

The microscope not only is of value in examining different kinds of flour for the purpose of seeing what mixture of other cereals have been added besides wheat, but it is also of the highest importance to the baker in judging of his yeast, because he will be able to see whether he has the organism which will produce acetic acid which would make vinegar or lactic acid, which would produce sourness, or even a worse organism still.

The particular process I have been describing, for making bread then, depends on making carbonic acid gas from the decomposition of the sugar which has formed in the previous stages yielding carbonic acid gas and alcohol. I have said very little about the alcohol; it is with the carbonic acid that we are chiefly concerned. There are other methods, however, of aërating bread without the carbonic acid of fermentation; bicarbonate of soda, and hydrochloric acid, when added in proper quantities, so that one exactly neutralises the other, or at least so that the bicarbonate is slightly in

excess, is another method of making carbonic acid; or there is Dr. Dauglish's plan for making aërated bread, which depends upon aërating the bread with carbonic acid made in chemical ways, not by making use of the yeast organism. The hydrochloric acid and bicarbonate of soda method has very grave objections, because it requires very great care in mixing them, so that you should not have too much bicarbonate on the one hand, or too much hydrochloric acid, or spirits of salts as it is called, on the other. Dr. Dauglish's method has its merits, because you do not introduce anything into the bread like hydrochloric acid or bicarbonate of soda; it is merely carbonic acid that is introduced, and it has for some years been used in London, and one or two other towns. For a long time apparently it had no very great measure of success. It is very interesting, because this method is an entirely mechanical one, and it gets rid of many of the objections which have been brought to the fermentation plan and to the hand method of kneading. I understand that during the last two or three years a greater sale has been found for aërated bread, which shows that the objections which I have for it have not been entertained by those who like it. I find that aërated bread is very nice the first few times of eating it, but after a time I long again for the nutty flavour of the well-fermented bread.

High-class flours and a skilful baker will make good bread. The real difficulty is to make good bread with flours that are not derived from highly elaborated wheats, and this is a point that I wish to say one or two words about before concluding. The Council, of course, desire the greatest extension of knowledge throughout the country, and inasmuch as we only grow one-third of the wheat we eat, and we are always obliged to import two-thirds, it seems to me that even in seasons that are not very favourable we have a remedy in our hands. In other words, as I have pointed out to you, where it is that so much injury takes place is in the sponge stage. It seems that we should divide our flours. Every miller should send out two distinct flours.

A few years ago I recommended that, and there are many millers who do that now, and many bakers who use two distinct flours; but I wish the recommendation I made at the Society of Arts should by means of the cheap publications of this Exhibition be more generally known. In order to show you that this is a very feasible plan, I have asked Messrs. Hill of Bishopsgate Street, to make me an experiment to illustrate it. I preferred not to have anything to do with it myself, in order that it should not be a lecture experiment in which one is liable to exaggerate. I asked Messrs. Hill through Mr. Dunham to get some good American flour and some soft Norfolk flour—not bad flour, only rather weak. Then I asked them to have them in the proportion of one-quarter American to three-quarters Norfolk. One set of loaves has been made in which the American flour has been kept separate, and only used for the sponge state, whilst in the other experiment the American and Norfolk flours were mixed, and used both for the sponge and for the dough. Loaves were made at precisely the same time, the same flours, the same quantity, the same salt, and baked at the same temperature, and *here* is the result. Those who are interested in the matter will see that in the case where they were mixed the loaf has not risen well, and in addition to that it is not so good in colour.

With reference to the use of brown meal, or whole meal, I would suggest either that you should make your sponge of very fine sponge flour, as a baker would term it, good hard whites, and then in the dough stage mix up the whole meal into it, or if there is an objection to this, that it is diluting your whole meal; then I would suggest another matter of getting over the difficulty. Make first of all a ferment, and in the ferment take care you use potato and flour as I have indicated; then add in the second stage a small quantity of glucose, using however in the sponge nearly all the salt and using a large quantity of yeast, pushing on therefore the sponge stage rapidly; then mixing up

the remainder of the whole meal, and rapidly making your bread and baking it.

I did intend to call your attention to some drawings of the Vienna oven, to show how foreign rolls are glazed, but I will not detain you any longer. I will only ask you when you have the opportunity at the Exhibition to go round to the east corridor to Mr. Hill's exhibit, and there are one or two others, who are also making these foreign breads, and you will there see the process of glazing these rolls. It is done by steam, which is what we term super-heated. It is forced into the oven which is at a temperature of at least 500 degrees, and the steam coming against the hot walls of the oven becomes super-heated, it then passes over the surface of the roll, and glazes it or covers it with dextrine. I will only detain you with two or three other remarks. In the baking the cells of the starch are burst, which renders the bread easily digestible, the carbonic acid gas bubbles are enlarged, and that together with the expansion due to the steam enables the bread to be well piled. The crust keeps the moisture in, and from the elaborate experiments made by Lawes and Gilbert, Dr. McLagen, and our distinguished chairman many years ago, we now know the exact percentage of moisture that may be found in ordinary quartern loaves. To put it in another way, 100 lbs. of flour will give about 135 or 136 lbs. of bread ; in other words, a sack of flour will give 96 loaves. I dare say one or two practical bakers would say that fine flour would give even more.

I have called attention to the chemical phenomena underlying a very important industry ; I have asked your attention to this experiment, made for me by Messrs. Hills, and I will also ask you to notice the exhibit of Mr. Bonthron, No. 179, in the main corridor, to see the character of his crude gluten. I have some on the table, some dry, and some mixed with water, and I would ask you to notice the excessive tenacity of this gluten. If I have contributed anything to show how wheats that have not been well

elaborated may yet be used with our foreign importations; if I have in any way, not merely to this audience but to the still larger audience, I hope to address by means of the Exhibition publications; if I have called your attention and that of others to interesting exhibits which you will find all through the building connected with bread and corn; and if I have shown you the importance of science to the advancement of this technical art, and caused you to take an interest in the scientific phenomena on which it is based, I shall not have failed in the object with which I came here to-day.

The CHAIRMAN, in moving a vote of thanks to Professor Graham for his exceedingly interesting, scientific and practical lecture, remarked that if none but the best qualities of wholesome food were used, the prices would evidently rise to such an extent as to seriously interfere with the supply; but science was able to teach how to employ inferior qualities of that which was nevertheless essentially wholesome so as to succeed in producing the result which, if not quite the best, was at any rate of a highly satisfactory character, and all must feel that Professor Graham's efforts towards the elucidation of that problem in the case of the conversion of flour into bread were worthy of the most hearty vote of thanks which could be accorded to him.

Mr. BONTHRON, as a practical baker of forty years' experience, begged to second the vote of thanks. He was very pleased to find science following so closely on the heels of observation and experience. He saw several practical bakers present, and he would call their attention to the very important consideration arising out of what they had heard, *viz.* the importance of the time to be given in London sponge to first-class flour, in order that the proper change might take place. This was a matter he had a great deal of difficulty in impressing on his workmen, but there was no doubt that the fine flour required longer time to undergo the necessary changes, and it must not be supposed for a moment that it could be done

hurriedly. You could not ripen a grape properly except by the natural sun and by the natural time, and the same thing applied to bread-making. He had been much struck with the diagram of the ferments. It was well known that heat accelerated and cold retarded fermentation. In this particular season of the year yeast must be in a condition in which it was necessary that every care should be taken to nourish it. There was a serious danger of putting yeast which was weakened by warm weather into too cold a ferment. It should be tenderly nourished, always put in with a good body of food for it to work upon, never into the water, but always after the flour and other matters were put in.

(The vote of thanks was carried unanimously, and the proceedings terminated.)

THE SCIENCE OF COOKERY.

BY

W. MATTIEU WILLIAMS.

JUNE 9TH, 1884.

A LECTURE ON THE SCIENCE OF COOKERY.

By W. MATTIEU WILLIAMS.

LADIES AND GENTLEMEN, the subject which I have to speak about is the Science of Cookery, and I wish to dwell particularly on this word science, seeing that there are many ladies here, some of whom may be very critical, and therefore if I were to attempt an exposition of the *art* of cookery I should probably be tripped up rather ignominiously. But the science of cookery and the art of cookery are distinct, although necessarily connected. There can be no true art without science, and in a practical subject of this kind the scientific part includes a generalisation of the facts which have been brought forth by the artist; therefore, I shall have to assume that you know all about the results of cookery, and what I have to talk about will be the rationale, the nature of the action that occurs in cookery. Suppose, for instance, I take the very simple cases of a roast leg of mutton and a raw leg of mutton. These are very familiar objects, but I venture to say that if 100 or 1000 persons who pass the Griffin, where Temple Bar used to stand, were asked "What is the difference between a cooked and a raw leg of mutton?" it would be found by the large majority to be a very curious conundrum. They would know there is a difference in the flavour, but not what are the changes that are effected in the act of cookery. This is a chemical ques-

tion ; this is a scientific question, and I must say that since I have taken up this subject somewhat recently (I went into it some years ago when I was at Birmingham—but lately have studied it more fully) I have been much surprised at finding how little I am able to learn from books compared with the number of the questions that suggested themselves in the course of writing the series of articles which I have contributed to 'Knowledge' during the last twelve months. A number of new questions have cropped up which demand a considerable amount of special investigation for their solution.

Perhaps I may add, in the way of introduction, that nearly one hundred years ago the subject of cookery was scientifically investigated, by one man, a most wonderful man—a man who began life as a poor schoolmaster, who became a great general, a great statesman, a great scientific man who was Dictator and Governor, taking the place of the reigning Duke of Bavaria for a while, and keeping his enemies at bay ; I speak of Benjamin Thompson, better known as Count Rumford. He did investigate cookery, and applied the science of cookery to the art ; for great as he was in war, great as he was in statesmanship, that which he evidently regarded as his greatest triumph was his economical cookery, the fact that he fed the poor of Munich, the beggars, thieves and vagabonds, which abounded there to a fearful extent, for less than 1*d.* a day with good nutritious and appetising hot food. The daily dinner provided by him at the House of Industry for 1200 persons, each receiving a portion weighing 20 ounces, cost altogether £1 15*s.* 2½*d.*, about $\frac{1}{3}$ of a penny each, $\frac{422}{1200}$ of a penny exactly. He studied the subject scientifically, and brought to bear upon it all the science of his time ; but we must remember that chemical science scarcely had any existence then, it was but in its infancy. The doctrine of phlogiston had only just passed away, and oxygen had but just been discovered.

The science of cookery is still a comparatively new subject, but the work that is done in practical cookery in

South Kensington, and the attention we are now giving to it, will I hope lead to a considerable further extension of our knowledge. But I must not spend any more time on preliminary remarks, but go directly to the subject, apologising again for the fact that I have only one lecture. The subject is very extensive, and I can only touch on some salient parts of it, for it would be impossible to go through the whole in anything like the time permitted me.

In ordinary cookery the chief agent is heat, and the changes that occur are those changes which can be brought about by the application of heat; the art of cookery is to a large extent the skilful application of heat. I am speaking now of the simple forms of cookery. I will take some of these first. As you are aware, a body may be heated either by radiation or by direct contact. We may stand in front of the fire at a little distance from it and be warmed, or we may touch the bars and be warmed in doing that, or we may dip our fingers in hot water and be warmed thereby. In the two last cases there is contact with the heated body. In the first there is not contact with the heated body, but we take advantage of the fact that heat radiates, is thrown off in all directions, and thus we get it applied without contact. Now you will at once be able to generalise this, and see in which of the processes of cookery radiant heat is applied, and in which we have the heat of contact. Roasting, grilling, braising, toasting, and baking, all these are done by radiant heat. Boiling and frying—that is frying as it ought to be done—and stewing, are examples of cookery by contact. In what we call boiling anything—though it is a misnomer, for when we say we boil a leg of mutton we do not boil the mutton any more than we boil the kettle; when we say the kettle boils, it is not the copper or the iron, it is the water that boils, and when we say we boil a leg of mutton, or a potato, or an egg, we make a mistake, and rather a dangerous one, because a cook may be misled by words. What we call boiling is nothing more than using hot water as a means of communicating heat; it is heating by means of a water

bath. We want to warm the food, and we use hot water merely to convey the heat to the thing to be cooked, whatever it may be. The same with frying; but here we use a bath of another kind, or ought to do so, a bath of fat.

Before I go into other details, let us take this little instance standing before us at once, and ask what is the difference between boiling and frying. In both cases we have a bath; what object do we gain by using a fat or oil bath rather than a water bath? I say a bath, because in this country we have an old, hideous, and absurd apparatus of this kind (an ordinary frying-pan), which, except for pancakes and omelettes, is a barbarous abomination. I am sure if there are any ladies here from the South Kensington School of Cookery, they will agree with me in denouncing this thing. We have also another apparatus of this kind (a frying kettle), which I borrowed from one of the stalls here, which is the correct thing. If you have to fry a sole, you may have a piece of iron like this frying-pan, and grease it well, and that will keep the sole from sticking to the iron, which was my idea of the use of the fat when I was a boy; I thought they greased the pan simply to keep the food from sticking to it; and even at the present day, there are many grown people and even some cooks who think that such is the whole function of the grease in the frying-pan; but according to the definition I have given you of frying it must be something quite different. You want a bath of fat, and when this frying kettle is used—there are many forms of it—you have a bath two or three inches deep in fat, and a wire tray by which you can easily lower the article to be fried into the bath, and take it out. Now at first sight this fat bath may appear to be wasteful, but those who have tried it know that it is more economical than the greased sheet of iron. They know perfectly well that when they use a bath of fat like this, in which the thing to be fried, the sole or whitebait, or whatever it may be, is completely immersed, if it is skilfully managed and taken out in a proper manner and allowed to drain for a short time, that

there is less fat wasted and less fat used than when only a smear of fat is put on the iron, that has to be wiped off afterwards and got rid of, whereas this fat bath may be used over and over again, with proper precautions to purify it, and the minimum quantity of grease goes into the thing to be cooked.

I show this because it is necessary to understand that when I speak of the rationale of frying, I assume this kind of frying; I assume that the sole or cutlet, or whatever it is, is cooked in a bath of fat kept at a temperature far above that of boiling water. Why it is that less fat enters it I shall explain presently. The difference then between boiling and frying depends on the fact that liquid water cannot be heated above the temperature of 212°, unless you put on pressure; you can in a high pressure boiler, but that is out of the question altogether. Water exposed to the air can only be heated to 212°, because of the evaporation which takes place and carries off the heat; nearly 1000° heat are carried off for every unit of water evaporated, and this keeps down the temperature. Therefore when the water bath is used the cooking is effected at that limited temperature. When the fat bath is used a higher temperature is applied outside the food, but not within it. This perhaps will require a little explanation. Ordinary animal fat, such as lard or dripping fat, or oil, cotton seed oil (which is now used largely for frying, and does very well), have boiling points as high as 400° or 500°; in fact you cannot boil them at all without the help of a vacuum, because at the boiling-point they begin to decompose; as they reach the boiling point they are carbonised. The temperature at which they just begin to boil is sufficient to brown or carbonise food, to convert sugar into caramel, or if you put a piece of paper into it you brown that paper.

Suppose you take the ordinary bath of fat; you remember that when it is first put on the fire it makes a considerable noise, and appears to boil. But it is not the fat that is boiling at all, it is the water that happens to be in the fat; and if you go on long enough—keeping it up to

about 300°—you will have driven out all the water boiled it away, and then the frizzling ceases. But, now, suppose you have this bath of fat raised considerably above the boiling point of water, and then you put a sole or a cutlet into it. You know what happens,—a great noise begins, a great frizzling and crackling. What is it? It is a series of little explosions that occurs. The sole or the cutlet, or whatever it is—any kind of animal food—that you put in contains water, and the water that is in it is made to boil; and, as it boils very violently and very suddenly, the bubbles of steam burst explosively on the surface of the fat, and this multitude of minute explosions constitute that hissing noise that occurs the moment you put the wet substance into the heated fat. You will understand something else from this in the rationale of frying, that, although you immerse the fish or flesh in fat that shall be heated to between 300° and 400°, you cannot get the interior of the food to such a temperature so long as any water remains within it. You are only heating the interior of its substance to 212° or a little above; just that little which is due to the pressure that is put upon the steam in getting out. When you are frying a sole in a bath of fat, the inner part of the sole is really being steamed; it is being cooked in its own steam, which steam is generated by the heat surrounding it.

So much for the interior; but, as you know, there is something else that happens outside, it gets brown. The chemistry of browning is one of the problems that I encountered very early in studying this subject. I have looked up all the works on chemistry and cookery, but have not discovered any deliberately wrought-out explanation of the philosophy of browning. There is a great flavour due to this browning, as was pointed out by Count Rumford. He used as a roaster a chamber in which he raised the heat to a certain extent, and then blew very hot air into it to brown the surface. That browning unquestionably gives a flavour that most of us like, and if a sole were fried without being brown on the surface, or without having the material

laid over it browned, we should consider it insufficiently done.

The *rationale* of browning, so far as I am able to make out is that the action is analogous, if not identical, with that which is well known in the kitchen as caramel making. You know that if sugar is heated it fuses at about the boiling-point, and it gives off vapour. If you go on raising the heat, it gives off more vapour of water, although it be dry sugar. First of all it becomes barley sugar, or amorphous sugar, not crystallized; then it gets darker, and with skill the French get a beautiful pink or crimson sugar; then you get to the brown toffy, still soluble; then the caramel, which is used as browning; you may go on until it becomes black, a mere charcoal, and tasteless, but up to the caramel stage there is very decided flavour. The same thing may be done by treating sugar with something that takes away the water, sulphuric acid, for instance; you may have seen that experiment. The composition of sugar being carbon and the elements of water, the removal of water carbonises it, and it is this carbonising, or caramelising, which occurs on the surface of roasted meat. You have there carbo-hydrates, which, like sugar, can be caramelised or carbonised in varying degrees. This theory, I think, has an important practical bearing, because if this caramel flavour is desirable, it suggests to the cook the more extensive use of caramel itself. I do not pretend to be a practical cook, but this brings us to a general practical conclusion. I think that in our English cookery we should do well to make much larger use than we do of the various forms of caramel. We do use a little burnt sugar for browning gravies, but there is a multitude of other caramels, such as the burnt onion, for example, that is used in France very much.

I had a *6d.* three course dinner here to-day in the vegetarian dining-rooms, and I confess I was disappointed. I strongly sympathise with those enthusiastic ladies and gentlemen who are working in this direction; I believe they have some very strong arguments, but I do not

think they will succeed until they are better cooks than they are at present. I knew one vegetarian, Arthur Trevelyan, in Edinburgh (a brother of Sir Walter Trevelyan, who gave his wine to Dr. Richardson), who was a vegetarian, and when he bought the Pencaitland estate, he was called the "cabbage Laird" by his tenants, and others. I have often spent the day there and dined with him, he had a very skilful cook, and his vegetarian dishes were delicious. There were trout in the river close by, and he was always ready to offer me trout or game or anything of that kind, but I preferred to join him in his vegetarian dinner. I noticed that most of his dishes were brown; they had brown gravies; there was caramel, there was burnt onion, there were mushrooms, and a variety of other things. The dish he called a vegetarian rump steak was far superior to any made from beef I have ever tasted. It was a kind of omelette with mushrooms intermingled in such a manner that it had the appearance and very much the taste of animal food. I mention this in passing, because I think the possibility of vegetarian diet depends very greatly on cookery; in fact I may as well confess my faith in this matter. I am a vegetarian to this extent; I believe the food of the future will be vegetable food, and that future will approach just in the proportion as the science and art of cookery advances. At present we get our vegetables prepared by means of the digestive organs of sheep and oxen. The chemistry of animal and vegetable food shows us that everything contained in animal food exists in vegetable food, but it requires preparation and selection. Our present mode of eating grass in the shape of beef and mutton, for that is what we do, is rather a barbarous practice, and I am convinced that if scientific cookery were understood and carried out, we should be able to obtain directly from the vegetable world all the food we require, and get it in as digestible and as easily assimilable form as any animal food by preparing it scientifically and chemically in the kitchen, but at present we have not learnt to do this, and therefore a considerable amount

of progress is necessary before the vegetarian millennium comes about.

Before going further, I should like to say a word about the cookery of water. If you put water in a glass vessel and watch what occurs when heat is applied, the first thing that happens is that some bubbles of air rise; then you will see larger bubbles adhering to the bottom, these are bubbles of steam, and presently boiling occurs when the steam passes right through. The first thing that happens is the driving away of air that is dissolved in the water, and after that the boiling begins. Then is there any such thing as the cookery of water? I say yes, and a very important matter is this cookery of water, because, unfortunately, a great deal of water, perhaps most of the water we get, is liable to organic impurities which may be dangerous. How can we get rid of this danger? One way is simply to boil the water, but then you say it is insipid; so it is, and the reason of such insipidity is the absence of air that is dissolved in ordinary water. One remedy for this is to agitate the water in the air, and let it take up a new supply; another is to pump into it a little carbonic acid, for that is the main requirement. Passing down the Exhibition I saw this Salutaris water, which I use myself; here we have a very good example of the cookery of water. I am glad to see this company working in this direction; they distil the water so that you get only the condensed vapour, and then by forcing into that some carbonic acid you get cooked water, perfectly free from impurities, without that faintness or insipidity which is so objectionable. I am willing to puff their aerated distilled water on every possible occasion, *on one condition*, viz., that they sell it in the streets at one penny per glass, and thereby become efficient promoters of practical temperance.

Now, I must pass on to consider the changes that take place in the cooking of meat, say a leg of mutton. We know there are two parts, the fat and the lean. The fat is simply fused to some extent, and I believe from experiments I have made, that it is a little altered in composi-

tion. There is a slight separation or partial dissociation of the fatty acids from the glycerine of the fat, but as that is a question which may be open to some controversy, I will not go into it now. Let us take the lean of the meat; what is that composed of? There are the muscular fibres, the fibres that by their contraction produce all the mechanical movements of the body. These fibres themselves are extremely minute, and require a microscope to define them when they are separated; they are of two kinds, the striped and unstriped. Each of these minute fibres, finer than a hair, is enveloped in a sheath, these sheathed fibres form bundles, and these bundles are enveloped again and form larger bundles; and thus the muscle is made up, and the muscles terminate in a tendon. The enveloping sheaths of the fibre, and the enveloping sheaths of the bundles, and the material of the tendon, all consist of gelatine, with some modification; and gelatine is also the basis of the bone, which is a complex structure of gelatine and phosphate of lime. So that if you take the body of an animal, like an ox or a sheep, looking at it generally, about half of the whole animal is gelatine; half of ourselves is gelatine. The cookery of this gelatine is therefore rather important. There has been a great controversy, which I must not enter upon, as to whether gelatine is nutritious. I may mention in passing, without going into the argument, that it was supposed not to have any nutritive value, but that has been refuted. It has a nutritive value, provided it is not taken alone. By the way, there was a case of the study of cookery which I ought to have mentioned before; a commission was appointed many years ago by the French Academy; it sat for ten or twelve years, and the problem was whether nutritious soup could be made of bones; it was called the "bone soup" commission. One experiment led to another, and another to another, and yet after all, they finished with a blunder, by concluding that gelatine was not nutritious, which has been disproved. The error arose from feeding dogs on gelatine *alone*, and finding the dogs died; this was because something else was necessary besides

gelatine. As far as I know the cookery of the gelatine consists simply in a certain degree of hydration and softening. The gelatine as it exists in the animal is not soluble in cold water, but if you take the gelatine, and boil it in water, or keep it heated for a time in water, it becomes altered. It still has the same appearance if you evaporate the water away; you get the insoluble gelatine converted into a soluble form. Some authorities describe the one kind by spelling it with an "e" and the other without an "e." I do not think that is of much importance; you may call one soluble and the other insoluble gelatine. In isinglass you have natural gelatine, the swim bladder of the sturgeon, or sometimes other fishes, cut into shreds. Now you know if you want to make a jelly from this form of gelatine, that it takes a considerable time to get it dissolved; it is all soluble ultimately, but only by a long process; and consequently there are many preparations of gelatine in the market which generally have a yellowish colour. I have examined the composition of these chemically, and I find the change is due to what a chemist would call hydration. The difference between the original membrane, which is the raw gelatine, and the gelatine which is thus cooked, is due, if I am right, to the chemical combination with a small quantity of water; this hydration occurs in many operations of cookery, and is something that ought to be understood. We have a whole class of chemical substances which are called hydrates, or compounds with water. The difference between anhydrous bodies and hydrates is considerable, and this is one instance of it. My explanation, then, of the cookery of gelatine is, that it is a process of hydration.

Now, in effecting this hydration it is necessary to attend to a few points, one of them is very well brought out by the carpenter with his glue pot; carpenter's glue is merely dirty gelatine; it is the same as the calipash and calipee of the Alderman but impure. The carpenter knows that if he subjects his glue to a dry heat above 212° he spoils it, he carbonises it, and therefore he always cooks it in a water

bath; his glue pot is a vessel placed in water. That is a safe way to keep down the temperature below the boiling point; to heat it with water at such a temperature that it shall combine with water instead of losing water.

There is another change that is better understood, and which you find explained in most books. Take our typical leg of mutton which has to be cooked. The change I refer to, and a very important change it is, is that which is due to the solidification of one of the juices of the meat. In between the fibres, as you are aware, there is a quantity of liquid, and that liquid is rather viscous. The liquid is composed partly of albumen and partly of certain soluble salts, kreatine and kreatinine, salts of potash, phosphates, and so on. Albumen, which is typically seen in the white of egg, is a highly nutritious material, and one upon the cookery of which the difference between cooked meat and spoiled meat mainly depends; and in order to understand the art of cookery, this part of the science should be very clearly made out; the properties of albumen should be studied and carefully understood. Now, the change which heat effects in albumen is that of coagulation. It is a viscous liquid, and its function in the animal economy appears to be partly that of a lubricant. In the joints it is poured out as synovia, "joint-oil," as some people call it; it also exists between the fibres of the muscle, and you all know by just rubbing in your fingers a little white of egg what a beautiful lubricant it is. However, our business with it is as an element of nutrition. Suppose you take some white of egg and carefully warm it in a glass vessel so that you can watch it. You will find that at about the temperature of 134° it begins to change; little threads or films of opaque material are formed within it; at 160° it ceases to be liquid, and becomes so jellied that if you had it in a glass you might invert it, without pouring it out, but still it is a jelly which trembles, and is very tender. Going on heating it to boiling point, to 212°, it becomes more and more opaque, loses the transparency it had as a jelly, and becomes a

hard substance; and if you go on and keep it at 212° long enough, or heat it beyond that, you get a substance so hard that it makes an admirable cement. An old-fashioned and very good cement for broken china is simply to smear it with white of egg, put it together and heat it in an oven. That shows what you get by over-cooking your albumen; instead of a tender digestible substance you get a hard indigestible cement—you ruin it as food.

You can easily try this experiment in another way; take a mutton chop or thin beafsteak and stew it, as it is too often stewed in boiling or "simmering" water. It curls up, and when you try to eat it it requires teeth of wonderful power to get through it. It is something midway between what meat should be and what gutta-percha is. That is the result of having hardened your albumen. Not only does it harden, but it shrinks a little, and that causes the curling up. Now try another piece of the same beef, but instead of putting it in boiling water, or simmering water —I have a dreadful animosity against that word "simmering"—put it in water that shall not rise above 160°; never allow it to boil at all. Boiling is an abomination in the cooking of meat, and ought to be scrupulously avoided except in the one instance I shall presently give you. In order to make sure of this use a carpenter's glue-pot, if you have not got a Bain Marie. You thus have the boiling water in one vessel and the meat in another vessel of water inside this. Then the evaporation from the inner vessel will prevent the possibility of its reaching the temperature of the outer; the outer one cannot get above 212°, and the inner will be considerably below it. A piece of beef stewed in this water at about 160° will be tender, and in every respect superior in digestibility to that which was curled and hardened by boiling or "simmering."

This is the way it ought to be stewed, and this is the way the French, Italians and Spaniards cook their meat. They have very little of it, and they make it go a long way. I have seen a great deal of the Continental peasantry—I am not speaking of the Parisian restaurants and their luxurious

cookery, they are of very little consequence, but about food for the million. The poor peasant with her 2 or 3 ounces of meat for a large family puts it in a *pot au feu*, along with what vegetables she happens to have, puts it in after breakfast and leaves it there; it never gets up to boiling-point; the meat and vegetables are intermingled, and a nice dinner is obtained for about one-third of what it costs our people of the same class for a lump of salt bacon. I have often shared the meal of a French and Italian peasant, and I prefer it considerably to the ill-cooked food which costs our artisans so much more. I believe that bad cookery is one of the sources of the drinking that prevails; it causes the craving for drink. I once had an experience of this when, having starved for four or five days, I came to a good hotel were there was some good claret; I shall never forget the propensity I had to go on drinking it, and if I had not put a strong restraint on myself, I should have called for brandy after my St. Julien. It was a craving resulting from the want of food. I had been starving on bilberries in the mountains of Norway.

Another point in the cooking of meat is the retention of the juices. The juices of the meat are as essential to nourishment as the solid part of the meat itself; this is proved by the consequences of eating meat from which the juices have been taken out. The salt junk which the sailors have is meat which has been kept in pickle, and by that process which the chemist knows as *exosmosis* the juices of the meat come out into the pickle; the potass salts which are necessary for food are there instead of in the meat. The men eat the fibrine, the gelatine, and the albumen, but they lack the salts, and the result is some of the most dreadful and painful diseases from which humanity can suffer;—gout, rheumatism, and a number of other diseases, besides scurvy itself, are among the consequences. It is well known to Arctic voyagers and others that when men are thus suffering there are two ways of restoring them. One is to give them fresh meat in which

they get the salts, and another is to give them vegetables like scurvy-grass, lime-juice, or anything of that kind, containing potass. The juice should be retained in all cases where you do not drink the water in which the meat is cooked. Of course, we do that sometimes, and hence the difference between boiling and stewing. Boiled meat is meat in which we retain the juice of the meat in itself; stewed meat is that in which we take the juice out of the meat but serve it up with it.

To illustrate what I mean, I will take the small problem of boiling a leg of mutton. How should it be done? We want to retain the juices. Can we put a varnish over that leg of mutton—can we coat it with something? What I told you about albumen shows how we can do so. If you put the joint in boiling water, and leave it there for five minutes, or it may be perhaps ten minutes, there will be a shell of coagulated albumen outside. After that it should be boiled no more. What I should call the model way would be to use a Norwegian cooking apparatus, which is simply a box stuffed all round with non-conductive material, with tin case inside. Suppose you have started your leg of mutton, and have got that coating around it, if you put it in this tin with the hot water, shut it up in this box, and leave it here till next morning, you will have a beautifully cooked leg of mutton. This is one way, but it is an extreme case, although yachtsmen do sometimes adopt it. If they are going to have a boiled fowl for breakfast, they put it in boiling water over night, then shut it up and leave it; no more fuel is wanted, the heat is retained in the water, which is cooled below boiling point by the fowl, and thus they escape the danger of over-coagulating the albumen inside. Another way, and of course the practical way in ordinary cooking, would be, after having once given it that five or ten minutes' boiling, having formed that rind of hard albumen outside to keep in the juices, to take care that it shall not boil any more. And always remember that simmering and boiling are the same. If you put a thermometer into simmering water, and then make it boil

as fast as you can over a fierce fire you will find the temperature is just the same; it is boiling in either case. If bubbles of steam rise to the surface the water boils, and if water boils it is at 212°, and however hard you may boil it you cannot get it to more than 212°, unless you shut it up in a close boiler and put pressure upon it; therefore in every case of "boiling" or stewing any kind of meat the water must neither boil nor simmer. About 180° is the correct cooking temperature; that allows for the inner part to reach 160°, which is 52° below the boiling point, a very considerable difference. If you once cook a leg of mutton thus, watching it with a thermometer by way of testing it—ultimately, of course, you would have to do it without the thermometer—you will never wilfully commit the barbarism of boiling or simmering another. Of course it will take more time, because the heat has to pass through, and the heat passing through from 180°, takes longer than from 212°. In this way you soften the gelatine, and when that is done the cooking is completed. The same thing may be shown on a small scale with an egg. You know what boiling an egg is; another method is to put the egg in boiling water, take the vessel from the fire, and leave it about ten minutes, and then you get the white of the egg very soft. I tried an experiment, by putting an egg in boiling water and leaving it for twelve hours in an apparatus like this Norwegian Cooker, and obtained a very curious result not known before, namely, that when an egg is warmed equally throughout, the yelk of the egg coagulates before the white. In the ordinary mode of cooking an egg we have the white of the egg hard while the yelk is soft, but this is because the outside, when you only allow three or four minutes, is heated, and the heat has not got through to the middle; but if you gradually maintain the temperature as I did, keeping the heat in so that it gets right through, you have the yelk hard and the white as it should be, a semi-transparent jelly. You may get it right, with the white a soft jelly and the yelk the same, by allowing it a quarter of an hour in water of

about 180°. The same thing applies to cooking meat of any kind, or fish of any kind, or animal food, in fact, of any kind, by immersion in water.

The same principle applies in cooking a steak ; you can have grilled steaks, or you can have desiccated steaks ; you all know what these are. You know what excellent steaks bachelors and City men get in the City when they go to the grills. I made a number of experiments on that subject many years ago when I was a bachelor, and used to cook my own steaks, on scientific principles. My plan was this, —I do not say it is just the one which would do in an ordinary kitchen, but it illustrates the principle. Suppose I had only a small fire and wanted to cook a steak for my supper. I cut a piece off the fat, threw it into the fire, and made a great blaze, then plunged the steak into the middle of the flame and cooked it in that way. You will say this is dreadful, it will be all black and nasty. No, it is not so ; if I plunged it into a coal flame it would be, I should get a deposit of coal tar, and that is not a good sauce by any means, although we do make many things, and very savoury things, out of coal-tar by complex processes. But the flame produced by the fat leaves no flavour whatever. And when the steak was immersed in its own flame, the result was that the outside became hardened, so as to make a crust in the manner I have told you ; the fluids inside were trying to get out, expanding and loosening the texture of the meat, and thus making it tender ; they were heated and expanded, and in about three or four minutes the whole thing was cooked beautifully tender inside with a sort of crust outside. It is not necessary to have the flame, but if you have a clear topped fire, flame will not do any harm. If you have seen chops and steaks cooked where there is a proper grill, you will have observed that they are done in a very short time. There is not that lifting away from the fire, that fear that a little flame should splutter up, which troubles the domestic cook. The whole success depends on the rapidity of the cooking. That is to say, you should get a crust outside and just warm the

inside through, to a temperature of about 180°, then it is done.

I come now to a subject on which I have been making a good many investigations, the subject of cheese. You know that cheese is a constituent of milk, and the basis of cheese is one of those proximate elements which the chemist calls casein. It is very similar in composition to albumen and gelatine; it is an albumenoid nitrogenous food, and highly nutritious. It exists in milk in a soluble state, and it forms, with the cream and a very little albumen, the chief nutriment of the milk. There is a small quantity of albumen, the amount of which you can always ascertain very easily. When you boil milk there is a skin formed on the top, and that skin is coagulated albumen. Taking that away, what remains is water, fat, and the salts of the milk plus the casein. Now you know that casein is separated together with its associated fat by the action of rennet in making cheese. The rennet acts as a kind of ferment; it decomposes the sugar of the milk, forms lactic acid, and that lactic acid precipitates this casein or curd, a substance which is insoluble in acids. A great deal of cheese is now made without any rennet at all. It is made by using hydrochloric acid. Oil of vitriol, or any acid will precipitate the curd. This curd or casein is insoluble in acids but soluble in alkalies. Now we get in cheese one of the most useful kinds of food in existence. There is only 30 per cent. of water in it while there is above 70 per cent. in lean meat, or taking it altogether a cheese weighing 20 lbs. contains as much, nutriment as a sheep weighing 60 or 70 lbs.; and you have the advantage that your cheese is portable, that it can be stored and carried from one end of the world to the other as easily as you carry coal; all the difficulties of freezing, and all the rest of it, are superseded, so that you have here a most valuable food, and yet it is not appreciated. And why? This is a question of cookery altogether. We commonly eat our cheese raw, or if we cook it we make it worse. We cook it until it is brown; this increases the difficulty of diges-

tion. Cheese made brown is abominable. If you like to experiment on yourselves you can do so; I have done it; I have taken toasted cheese well browned for supper, and I have taken raw cheese for supper when hungry, and have had very eventful nights; a great many sensational adventures. On the other hand, I have had cheese carefully cooked, not brown—cooked with a little liquid so as to pour it over the bread, and I find I can digest this, and so can most people, but even then the cheese lacks something; it lacks those salts that I have described as so essential. I had a curious experience of this once. For five days I lived on bread and cheese on board a little schooner, where I had nothing else, and at the end of the journey I was in a state of semi-scurvy, craving for turnips, carrots, or anything I could get in the shape of vegetables, and a friend who was with me was just the same. This showed the want of salts.

I have lately been making a number of experiments on cheese with a view of rendering it soluble as it is in milk, in which state infants can digest it, and live upon it. I have tried to restore the casein to its original form by simply neutralising the acid which precipitated it, and I have succeeded in doing so variously. My first experiments were quite successful, but some of the after experiments were not so, when I used a different kind of cheese. I first operated on some mild Gloucester cheese very successfully indeed, and afterwards on some American cheese with mixed results. With the Gloucester cheese, by adding a little bicarbonate of potass to water or milk, about one-sixth or one-fourth of an ounce to a pound of cheese, grating the cheese or cutting it in thin slices, and slowly heating it, I completely dissolved the cheese. You may partially dissolve it without the aid of potass, but with the aid of potass I get a complete solution, and the potash combining with the lactic acid supplies the necessary salts that are otherwise wanting. The quantity I name, $\frac{1}{6}$ to $\frac{1}{4}$ of an ounce to the pound of cheese is about equal to the potash left behind in whey in the course of the cheese

making. This soluble cheese is, I believe, a most valuable nutriment, and may be used in a variety of ways. It may be mixed with porridge, for example, or with rice or potatoes, or with a multitude of things; it may be mixed with vegetables of all kinds; worked up with maccaroni or with eggs and flour, making a most nutritious dish, and very economical.

I had intended to have told you of some experiments I have made with vegetable casein, or legumine as some call it, which is the nutritive element of peas, beans, almonds, and such like. This also is difficult to digest, and by treating it with potass in the manner described, I have succeeded to a considerable extent in rendering it soluble, and, I think, more nutritious. This is a matter of considerable importance. You might say that having to go to carbonate of potass is rather too much like bringing the laboratory into the kitchen, but the addition of the carbonate of potass is merely restoring to the milk that which was taken out of it in the whey, and the quantity of potass I have named will not only render the cheese more digestible, but it supplies that kind of food in which the cheese is deficient. Cheese contains nitrogenous food, it contains fat, and when eaten along with bread, or with anything containing starch or sugar, you get a perfect food, only you are short of the saline constituents which I supply by means of the potash. The same with peas; peas are deficient, especially grey peas, in the saline constituents; they are not easily digestible although they contain so much nutriment. This is one of the struggles which vegetarians have. Peas and beans are their main stock, but they do lack those saline constituents, which I think may thus be artificially supplied.

There is another subject I may just mention in concluding, and that is what I call the ensilage of human food. You have heard a great deal about the ensilage of grass for cattle, but I hope we may do a great deal in ensilage of our own food. Here is a simple experiment you may try. Make some porridge, keep it in a cool place for a

few days and warm it up again, and you will find it will be more digestible. You know the old doggrel, "Pease-pudding hot, pease-pudding cold, pease-pudding in the pot nine days old ;" I believe that it has a hidden meaning, that if you keep pease-pudding for a while it becomes partly dissolved and more digestible. Experiments I am making in this way are only commencing, and I hope to be able to obtain some further results in this direction. There is a great deal to be done, because one experiment leads to another. For instance, when I dissolve the casein of peas, I find something left behind—fibrous matter. I find that an alkali dissolves casein, but I want an acid to dissolve the fibre ; and so one goes on. There are a number of subjects continually cropping up, and I should require a laboratory and two or three assistants to investigate them satisfactorily. I am therefore compelled to throw out many crude suggestions in lecturing and writing, hoping that what I cannot do somebody else will take up and carry out. If I have just been able to suggest to your minds that there is a science of cookery, and that the subject is worthy of further study, it is all that is to be expected from so short a talk on so large a subject.

PURE MILK.

BY

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A LECTURE ON PURE MILK.

By G. W. Wigner, F.I.C., F.C.S.

Pure milk is the natural food of infants, and in many cases the most appropriate food for invalids, and it may fairly be said to be essential to the growth of a healthy race of men and women. But it is even more than this: milk may be regarded as a model food, and as a complete food. It is a model food because it is nature's own food, designed for the sustenance of the young of animals, and, as such, it contains and furnishes all the nutritive properties in due proportion required by a growing animal.

It is a complete food, because it contains every element which is necessary for the support of the body and the activity of its functions.

Adults, who are living an active life, do not always require the constituents of food in the exact proportion in which they are present in pure milk, and yet there are few circumstances under which life cannot be sustained on milk, when properly taken, and with due care to ensure its digestion.

The food of man, in fact, of children also, most commonly consists of a compound of at least two or more animal or vegetable substances, the combination of which affords the various elements necessary to meet all the demands of animal life, and there is no other food in use which contains in one article all the essential constituents of food excepting milk.

Milk of course differs slightly, according to the animal from which it is derived ; and this point we shall have again to consider at greater length, but at present we must simply view it as a typically perfect food.

It would be hard to give any food a higher recommendation than this, and yet it is not too much to say that two-thirds of the inhabitants of London, or indeed of England, have any practical knowledge of what pure milk is, and that at least one-half of the remainder only consume it occasionally rather as a luxury than as an article of food.

Now milk is not only a perfect food, but it is the most extensively used food. Some might think, that this post of honour belongs to bread, but really I think it would be the food that, including children with the population, is used more extensively than even bread.

From pretty careful enquiry, it appears that the consumption of milk among the middle classes of London is something like 10 gallons per head per year ; but there are a large proportion of the poor to whom the cost of milk is serious, and there are a large proportion of the rich to whom, I am afraid, milk is less palatable than it should be ; and therefore it would be a very moderate estimate to say that, on the average, $3\frac{1}{2}$ gallons per head per year is consumed by the entire population, or say, $1\frac{1}{2}$ ounces per head per day.

Now London has been rendered somewhat notorious by the outcry about the amount of the Water Rates ; it will perhaps surprise some to hear that the amount of the Milk Bill of London is within about 10 per cent. of the amount of the Water Bill of London, and while the water rates amount to about £1,562,000, the milk rates, if so I may call them, amount to £1,400,000 per year, or about 5s. 10d. per head per annum.

There is a good deal of difference, however, in the actual incidence of the milk rate as distinct from the water rate ; because the poor, who have but little money to spare, are practically untouched by the water rate, their proportion of the landlord's tax being almost too small for consideration, while, on the other hand, they are among the largest

consumers of milk, and, unfortunately, from the very necessity of their purchases being small, say ¼*d.* worths, or ½*d.* worths, they buy from the worst vendors, and, without doubt, succeed in procuring the most heavily adulterated milk.

There are milkmen of various kinds in London, some of them of the highest integrity, from whom unquestionably pure milk can be procured at any time, and at a fair price; but it would be absurd to shut our eyes to the fact, that there are in London hundreds and even thousands of men, whose sole qualification for the trade consists in their ability to undersell their neighbours by watering their milk.

Milk consumers have, however, become so habituated to use the poor watered and skimmed milk which is supplied by these tradesmen, that the loss which they incur from day to day is not appreciated; and although their infants are deprived of the food which they require, the result shows rather an increase in the bills of mortality than an improvement in the character of the milk supply.

There is probably no more curious illustration in the whole of our English commerce of the way in which a trade may go on increasing with the increase of the population, or even at a greater rate than the increase, than the milk trade; and yet, despite of this increase, it bears a bad name, so much so, that the finger of scorn is pointed at it. From our earliest boyhood "Simpson" has been a common by-word, and comparatively few children of ten years old fail to understand what are commonly called the milkman's tricks. And yet, though the chalk-and-water talk of some twenty-five years ago, and the sheep's brains even longer since, are exploded fallacies, the bald fact remains, that milk is more adulterated than any other article that is sold in England; and the number of samples of adulterated milk, purchased by the inspectors under the Adulteration Act, are almost or quite as numerous as the adulterated samples of every other kind of food put together.

Of course milk has been a source of an immense number of cases of prosecution and litigation—persecution the milk

dealers call it;—but anyhow, whether it is persecution or prosecution, for close upon twenty-four years—that is, ever since the passing of the Act of 1860 for the suppression of adulteration—milk dealers have appeared in police courts, quarter sessions, and every other court having power to deal with such matters, not only from week to week and day by day, but many times a day, and yet milk adulteration goes on as fast as ever.

I shall have to refer to this subject in detail, with statistics, later on in the course of my lecture, so that for the present I want to point out simply, that there is a bright side to the dark picture I have drawn. I am not quite sure that it is possible to procure genuine milk regularly at the lowest price at which milk is retailed, say at fourpence per quart—exceptional cases may occur, say, for instance, when a public analyst is supplied,—but it is evident from practical experience that those milkmen who are not afraid to charge a price which leaves them a proper margin of profit can and do supply a genuine article; and I venture to say that by doing so, they satisfy their customers far better than if the price were reduced and the quality let down likewise. And considering the subject of pure milk, it is essential that I should first of all look at its constituents, and to some extent consider their food value separately and collectively.

Pure milk ought to be such a simple and straightforward term that it should not need definition, but legal sophistry has been exerted to such an extent upon the milk subject, and discussions of every sort have taken place in reference to milk, that even these two words differ in meaning according to the views of the persons by whom they are used. I define pure milk to be the milk produced by a properly fed cow in a state of health. I do not by this mean to imply for a moment that a cow should be fed to the highest pitch which modern science can devise, or that a veterinary surgeon should be kept in constant attendance upon it; but I do imply, that a man who puts forward his herd of cows as milk-producing machines, and sells the

milk which these cows produce to the public as genuine milk, is bound to take reasonable precautions to keep them in health, and such proper precautions as any man who values his stock would take, to see that they are sufficiently fed with proper food to prevent their deterioration in health and milk-giving power.

There are certain persons in the milk trade who distinctly challenge this view, and I shall not be putting the matter fairly before you if I do not state their arguments from their point of view, even though I state them merely to show their fallacy. The view which these representatives of a certain section of the milk trade take is, that any liquid which comes from the udder of a cow—no matter how much that cow may have been wrongly fed—is pure milk, and has a right to be classed as such, and to be exempt of the penalties of the adulteration Act. The leading argument which they put forward in favour of this view is, that the prize beasts of the agricultural shows have frequently given milk below the usually accepted standard of quality both as regards cream and solids not fat. I admit this fact without hesitation; it is well known, but the reason is not far to seek: animals at these shows are fed in such a way as to force the quantity of milk which they yield to the maximum, while at the same time the animals themselves are kept as far as possible in the highest external condition and calculated to attract the eyes of those who judge of animals by external appearance.

When these very same cows are taken back to their homesteads, regularly and properly fed, kept from the impure air of the show-shed or show-yard, and milked in a proper way, no such abnormal results are obtained, but the milk assumes the ordinary typical character, even when the quantity yielded is somewhat less.

This argument is what I may fairly call the legitimate one, although I have shown its fallacy; but in addition to this, there is used what I call the illegitimate argument, namely, that certain cows, improperly and imperfectly fed, in fact half-starved, have at certain times given milk below

the standard. The most notorious case of this kind is the old case of the cows at the Royal Agricultural College, Cirencester, which Dr. Voelcker admits were half starved, and I certainly cannot admit that milk produced by such animals as this has any right whatever to be classed in the category of pure milk.

Setting aside these two leading arguments against the standard set up, there is very little indeed to say against my argument, that pure milk should not merely be the produce of the cow, but should be the produce of the cow in a healthy condition and reasonably well fed. Granting, then, that this definition be accepted, in the first instance, we have to consider whether it is capable of being formulated in a more distinct way, so that, for instance, it would be possible for the milkman or analyst, by examining the milk, to say whether the liquid fulfils the conditions I have laid down; and here I am compelled at once to say No, it would not be possible; but the utmost that could be done by science and practical knowledge combined is that a certain limit may be laid down below which pure milk will not fall unless under circumstances of a most exceptional character. This limit is in practical use, and is adopted by a very large number of public analysts throughout the kingdom.

I pass now to consider the different constituents of milk, that is the various different parts into which it can be approximately divided, and into some of which, as a matter of fact, it is divided in the various processes of cream, butter, curd, and cheese making. These different constituents are Water, Fat, Caseine, Albumen, Sugar, and Salts, &c.; and for convenience of demonstrating the fact clearly, I have arranged on the table before me a series of bottles (which Messrs. Welford and Sons, who have the large Dairy in the Southern Gallery, have kindly placed at my disposal), that you may see the proportions of each of these ingredients contained in one gallon of milk. Here, for instance, we have the Water contained in one gallon of milk, which amounts to 8lbs. 7oz., and each of the other constituents in

its proper relative proportion. I ought at once to disabuse your minds of the idea that milk is absolutely constant in composition; it varies to some considerable extent, but in talking of it to-day, for popular purposes, I shall assume a fair average composition, and explain the extent to which the variations occur afterwards.

Fat is the most variable and probably the most important of the ingredients of milk. It certainly is the most important from a dairy farmer's point of view, because if the milk contains but little fat, he can procure but a small proportion of cream and make but little butter from it. From a dietetic point of view also, it is, I say, the most important, or most important but one, of milk constituents. The butter fat is a peculiar one, differing in many respects from all the vegetable fats with which we are acquainted, and differing also to a considerable extent from other animal fats. The most marked point of difference is in the fact that butter contains three volatile fatty acids, the principal one of which is Butyric, which, as far as we know, is not met with in any other fat, either animal or vegetable.

It by no means follows, however, that because butter fat possesses these peculiarities it is easy to identify it; on the contrary, it is only by a tedious and somewhat difficult process of chemical analysis, that the butyric acid can be so far separated as to enable a definite statement to be made as to the purity, or otherwise, of the sample of so-called butter fat.

Commercially we gét this fat in a state of what may be called "*semi-purity,*" as Cream. Good cream contains from 50 to 60 or 65 per cent. of butter fat, the remainder consisting of water and a small proportion of the other constituents of milk. When cream is churned into butter the envelopes of the fat globules are broken, and a large number of these tiny little spheres of fat, originally of microscopic size, adhere together, while a large proportion of the water and the soluble constituents are washed away with the butter milk. We thus get butter fat in a still higher state of purity.

Good butter, well made and well worked, should contain somewhere about 88 per cent. of pure butter fat, and the highest class of butters will contain rather more than this. To get the butter fat, however, in a state of purity, the butter must be melted with the water, soluble matters and curd separated; the clear limpid oil of beautiful amber-colour floats on the top. This, when poured off and allowed to chill, forms pure butter fat.

Fat in some form or other is an absolute essential to the dietary. If children are brought up without the use of butter, or a butter substitute, they rapidly lose health and condition, and even in many savage races, we find that the fat of animals is consumed in large quantities, taking the place of the butter of more civilised countries. Following out this argument, I see no reason why, with proper precautions in its manufacture, butterine should not be used to a considerable extent, to replace the deficiency of butter from which we at the present time suffer. Butterine, when properly made, is nothing but the best and purest dripping, flavoured with milk, so as to make it resemble butter as much as possible.

Yet, despite the value of the fat, skim milk, from which the fat has been removed, is a valuable diet, and when properly used, under medical advice, there is no doubt that in many cases of illness it would be more serviceable than even new milk. Unfortunately, however, the ease with which the fat can be removed, offers a considerable temptation to skimming.

The next constituent of milk that we have to notice is Caseine. This is the flesh-forming constituent of milk, and is called curd. It is classed as one of the most valuable constituents, and is a highly nitrogenous matter. Indeed, with the exception of a small amount of albumen and Lacto Protein, all the nitrogen of milk exists in the form of caseine. Caseine forms the basis of our cheeses of every kind, except the real cream cheese. It will therefore scarcely surprise you to hear that it is highly nutritious. We all know how hardworking men live, to a very great

extent, upon cheese with a quantity of bread, and not only do they thrive on the food, but perform an amount of physical work which most of us in this room would be quite incapable of undertaking. It is therefore fair to look upon caseine as being the work-sustaining portion of milk, and to say that if a sample of milk is deficient in caseine, it is deficient in a constituent most necessary for securing health.

Albumen constitutes nearly the whole of the remainder of the nitrogenous matter in milk. It is difficult to define the exact position which this albumen holds in the dietetic value of milk. It forms a small proportion, only about one quarter, of the nitrogenous matter present, but owing to its more soluble form, and the greater difficulty with which it is coagulated, it appears to me extremely probable that its real food value may be higher than the other nitrogenous constituents. There is some amount of evidence, although not yet a certainty, that this form of albumen is peculiar to milk, and that it differs from the albumen present in eggs, but it seems probable, that like the volatile acids present in the fat of milk, this substance has a special nutritive value of its own, and that without this albumen milk would not be a perfect or complete food.

Of course in the case of whey, which is not unfrequently used as a diet, the albumen forms a very important part, because the caseine, containing some three-fourths of the nitrogenous matter, has already been separated, and the albumen, with a trace of Lacto-Protein, form the only nitrogenous matter available.

Sugar of milk is a very peculiar sugar, differing from most other sugars. Nearly all its properties, both chemical and physical, differ from cane sugar, in not being so sweetening in its properties, and yet it has a pleasant taste, perhaps more agreeable in flavour than most of the glucoses and other uncrystallizable sugars. Sugar of milk itself, however, is crystallizable, but with a different form of crystallization to cane sugar or beet sugar, and its solution in water behaves differently during concentration,

a large proportion of the milk sugar present being deposited at a certain stage of the boiling, in an imperfect crystalline form, while the other part remains in solution. The polarization differs considerably from the polarization of any other known sugar. All these different points mark it out as a peculiar sugar. There is a good deal yet to be done in investigating the chemistry of sugar of milk, and it appears very probable that at some future time, further investigation may show that in reality what we look upon as a simple sugar, consists of different substances mixed together in proportions which are at present unknown. Sugar of milk is important in another way, as it forms the great point of difference between human milk and cow's milk.

Human milk contains a larger proportion of sugar than cow's milk, and less fat, caseine, albumen, and ash. It is from this that the formula generally adopted in the manufacture of artificial human milk is obtained; cow's milk is diluted with water, and then milk sugar added; by this means we obtain a liquid which assimilates somewhat closely in chemical composition to true human milk.

MINERAL MATTER.

This term includes a variety of salts which, physiologically considered, are of very great importance in the composition of milk. It is absolutely essential for the formation of bone and muscle that a growing child, or for the matter of that an adult, should be supplied with certain phosphatic substances, lime salts, etc. Milk contains these ingredients in the right proportions to form the bone and muscle of a child.

We now come to the water, the last and largest constituent.

Water, of course, strictly speaking has no real dietetic value, and yet without water milk itself would be useless as food, because it is essential that the valuable food ingredients of which we have already been speaking should be dissolved or emulsified, so as to be in a suitable form

capable of easy digestion, in fact so that the stomach can easily assimilate them. This water is the bone of contention between public analysts and milkmen, and nothing was more common three or four years ago than to hear a long cross-examination directed solely to the elucidation of the very knotty point—as to whether there was any difference between the water natural to milk, which in fact the cow put into it, and the water which the milkman added.

I should like to consider next, by the aid of a set of samples which have been lent me by the Aylesbury Dairy Company, the mode in which the milk is divided by the dairymen into the different articles of commerce which are most frequently made from it. The samples to some extent speak for themselves, and certainly as regards the first series, that of whole milk, I need not detain you any longer, except to say that here we have fat, caseine, and sugar, all shown in the same form as in the larger bottles on the table. Our next two series of samples here show us the division of the whole milk into cream and skim milk. Cream, as I took occasion to tell you some time ago, does not consist entirely of butter fat, but contains fifty to sixty-five per cent., more or less, according to its quality. And in this series of samples we have the cream divided into the constituents present in a good ordinary commercial sample, and you will see that some thirty per cent. of water is still present, and that this water carries with it caseine, albumen, and salts We may in fact put it another way, and say that, separate any particular constituent of the milk as carefully as possible by mechanical means, and we always find that some small proportion of the other constituents are present; thus, referring to skim milk: in the first separation we find that it still contains some fat; the amount in skim milk is extremely variable, according to the mode of manufacture. The Centrifugal machine, which you can see at work in the south gallery, is by far the most efficient and most successful for separating the cream from the milk.

The principle of the centrifugal separator is practically

identical with the principle of skimming, although the two processes appear so dissimilar. The milk revolving in the separator at great speed acquires immensely increased centrifugal force, which corresponds to the force of gravity. This centrifugal force acts more strongly on the heavy non-fatty portion of the milk and less strongly on the cream, and consequently the non-fatty part of the skim milk gravitates by the centrifugal force to the outside of the revolving circle, leaving the cream to flow away in the inside in an almost pure condition.

A few weeks ago I tried experiments with each of the separators at work in these dairies, and in some cases found the proportion of fat present in the skim milk reduced to even less than ·1 per cent.

These separators at the same time produced cream of high quality, and the skim that they produced is more palatable than skim milk obtained by the old process. I have known this statement to raise a smile on the faces of those who thought they knew all about milk, and have wondered how it was possible that one skim milk could be more palatable than another; but the reason is not far to seek: mechanical action in the separator thoroughly aërates the skim milk while it is fresh and has lost none of the aroma peculiar to new milk. Milk exposed to the action of air for twelve or eighteen hours in open vessels loses its aroma, and is apt to become contaminated by an impure atmosphere.

Here we have the other constituents of skim milk separated, by which you will see that we have a very small increase in the proportions of sugar, caseine, and salts, due to the proportion of fat that has been removed.

Our next array of samples shows us a further subdivision. Here we have the cream divided into its two constituents of butter and butter milk. Still the same rule holds good of the constituents of the original milk passing through, though in diminished proportions, into the finished product. Thus butter always contains milk, sugar, and caseine or curd, and even soluble albumen is not entirely

washed away with the butter milk. Still the butter milk, as we see by the central bottle, retains fat, true butter fat, which of course represents so much waste in the process of butter-making.

Taking the other side of our case, where the skim milk heads the column, we have skim milk divided up into cheese and whey. The cheese is represented here by the proportions shown. One of these types is skim milk cheese, with its very small proportion of fat. These cheeses are common enough, and are usually consumed in this country, but there are many cases in which the use of whole milk cheese containing a large proportion of fat is desirable rather than cheeses containing so little fat.

The proportion of fat contained in these cheeses vary, from skim milk cheeses occasionally to be met with containing as little as three per cent. of fat, up to cream cheeses in which the proportion of fat is largely in excess of the proportion of caseine.

Now every one of these constituents we derive from pure milk is capable of being adulterated. There are one or two of these adulterations to which it is necessary I should refer. The most serious portion of adulteration unquestionably is the admixture of butter with foreign fats, and the substitution of inferior fats for the true butter present in cheese.

We will take the latter first. A large number of cheese consumers desire a cheese containing a considerable proportion of fatty matter. This fatty matter of course ought to be the butter natural to milk, but butter is far more valuable than oleomargarine, and therefore extensive manufactories have been established for the production of oleomargarine cheese. This cheese is made of skim milk, skimmed by separators, so that the butter is practically all abstracted, the deficiency of fat being replaced by the addition of oleomargarine or lard, in sufficient quantity to make the cheese a tolerably fat one. I look upon this as an exceedingly flagrant adulteration ; the more so because it is one which is hardly likely to be detected by the consumer. There is no difficulty in detecting the fraud by an analytical

process. The very worst adulteration in the products is of course the use of oleomargarine to mix with or substitute for pure butter. I have nothing to say personally against the use of good carefully made oleomargarine as a substitute for butter, if only it is sold under its own name and at a fair price, but I have the greatest objection to its substitution for butter, which is more valuable and a more digestible diet, and unquestionably more suitable for domestic use. Good oleomargarine is nothing but the very best of beef fat carefully refined and carefully churned with milk, and as such no one can dispute its suitability for use as food; bad oleomargarine, on the other hand, is a compound of vile refuse fats, clarified and refined in any way that will chemically fulfil the object in view; but, to say the least, such a mode of preparing refuse materials for food use is objectionable, and the sale of the inferior sample should be in every way discountenanced.

I want to point out next the means which are available for ascertaining whether any given sample of milk is pure or not. In some respects this problem is comparatively a simple one, but in other respects it presents great difficulty. At the outset we meet with this difficult feature, that milk is a perishable article, and must be consumed within, at the most, a few hours of the time it was obtained from the cow. It follows from this, that it is not practicable for each sample of milk, or, for the matter of that, not one out of one hundred, to be subjected to chemical analysis before its distribution to the consumer; it is obvious, therefore, that some readier and more rapid test must be used or the milk must be sold without any test at all.

A good many different kinds of tests have been proposed for this purpose, and various instruments, under the name of galactoscope and other similar names, have been suggested, by which the degree of opacity of the milk could be read off according to scale, the idea of the inventors being, that the poorer the milk, the fewer would be the number of fat globules contained in it, and therefore the less the opacity of the milk. In practice these instruments signally failed,

in consequence of the fat being the most variable constituent in milk, and also from the fact that the opacity of the fat globules vary considerably.

The microscope has also been suggested as a ready means of detecting adulteration, but except in highly skilled hands this is even less useful, and may now be considered as obsolete as the other. For one thing, however, the microscope still retains and must retain its position: it is practically the only means by which diseased milk, that is milk obtained from diseased cows, can be detected.

One instrument however has survived, and is in constant use by many milkmen: this is the Hydrometer, or as it is more familiarly called in the trade, the Lactometer. This is a valuable instrument in its way, but the results obtained by its use are apt to be misleading, as it simply gives the relative weight of milk compared with water. One gallon of water weighs 10 pounds; one gallon of milk about 10·3 pounds; it follows from this that if the milk be admixed with water, the weight of one gallon would be reduced, so that supposing the mixture consisted of half milk and half water, the weight would be 10·15 pounds. Unfortunately, however, the weight of pure milk is not uniform; it ranges between the rather wide limits of 10·28 and 10·35. We therefore get a possible error introduced at the starting point, and this starting point or zero being erroneous, it follows that all calculations based upon it must be likewise liable to error. If, however, this were all, the instrument would still be a very useful one in the hands of a careful man, but experiments will soon show that there is another great drawback. If a sample of milk with a specific gravity of 10·30 be taken, and the cream carefully skimmed off, the specific gravity of the skimmed milk would be increased by the removal of the butter fat, which is lighter than water, so that the weight of the skimmed milk itself may be as much as 10·34 or 10·36 pounds. It will be seen from this that we have two different ways in which the milk can be tampered with

viz.: watering, which will reduce the weight of a gallon; skimming, which will increase the weight of a gallon. Both of these processes are profitable to the milk seller, and a moment's consideration will show that if the milk is carefully skimmed and afterwards watered, the original gravity of the milk will be reproduced so exactly as to deceive any person using the lactometer as a test. It is in this way that a good deal of the watered and skimmed milk is passed off by country dealers to the London vendors and by London vendors to their customers. In one case, however, the lactometer is serviceable, and that is to show that the milk coming from any farm keeps day by day a fairly uniform regularity in quality, and that the milk returned by the milk carriers at the conclusion of their rounds comes back in the same condition as when it went out.

The only reliable and trustworthy method of ascertaining the quality of milk, is by means of a full chemical analysis. To carry this out the water contained in the milk is evaporated; the whole of the solid matters of which I have shown you specimens are left behind in a state in which they can be weighed; the fat contained in these solid matters is then extracted by means of either petroleum or some other suitable liquid, and the solids not fat which are left behind are dried again and weighed. These solids not fat form the real standard by which the question of watering is determined; while the fat which has been extracted when weighed forms the real guide as to whether the milk has been skimmed. If either of these two figures were perfectly constant, one problem of milk analysis would be solved, but unfortunately there is a considerable variation in different samples of milk.

To get over this difficulty a low or minimum figure has been adopted as the standard, so as to allow an ample margin for the natural irregularity of composition. Milk dealers are aware of this difficulty in fixing a standard, and are constantly endeavouring to prove that adulterated milk is really pure milk. There is practically no

milk adulteration case ever brought into court in which any other defence is raised. The allowance is always said to be insufficient, and the unfortunate milkman has cows worse in quality than those which have been tested by the analysts, and consequently he obtains milk poorer in quality and worse in character than any which they have seen. This argument, however, has pretty nearly spent itself; it is only occasionally that there is any magistrate who is found to listen to it.

In conclusion, it will be interesting to notice the extent to which pure milk is sold in London. The returns which are made under the Adulteration Acts specify the percentage of adulteration found in each sample, while the tabulated reports issued in the blue books state only the number of adulterated samples, and taking the case of milk do not give the percentage of skimming or watering. This of course seriously diminishes the value of the returns. It is therefore surprising to find that only on one occasion during the last seven years has the percentage of adulterated samples of milk fallen below 20. Out of every 100 samples of milk purchased by the inspectors 20·35 were adulterated, even on the lenient limit of calculation used. But by looking to London alone you will get a better illustration still. At some considerable trouble I have endeavoured to find out what the quality of the average milk supply of London really is. Londoners within the area of the London water companies, supplies number nearly, or quite, four-and-three-quarter millions, say 4,760,000, and the cost of the milk supply is therefore a tolerably large figure.

The limit of pure milk has by almost (but not quite) universal consent been fixed at 9·00 per cent. solids (not fat) and 2·50 per cent. fat. My opinion is that this is if anything too low, especially in fat; so I procured 55 samples during the month of October from entire dairies of milk as the milk arrived in London. The farmers' men may have added a little water, but, unless in one case, I have no reason to think that this has been done. No

precautions whatever were taken to procure special samples, so I am fairly justified in saying that this milk is a fair sample of what dairy farmers can supply in London during the month of October. These deliveries are from the milk of about 2000 cows.

Out of this series of 55 samples, the solids (not fat) fell in one case to 8·93 per cent., with 3·14 per cent. of fat, and in the next lowest case to 9·10 solids (not fat); that is 54 out of 55 samples are above the limit, and the one remaining sample has a high proportion of fat; but the average is more important, and this comes to solids (not fat) 9·60, fat 3·46, total solids, 13·06; so that the average of these 2000 cows is at the very least six per cent. above the limits used by the Society, and nearly 40 per cent. higher in fat.

So much for what comes to London: now let us see what is sold in London.

It is proper to expect that *some* of the best milk should be delivered, for however leniently a milk seller may generally look upon watering, we cannot expect that all of them do so.

I purchased 300 samples in London, and three out of the 300 corresponded with the average of the milks sent to London, and one of the 300 was richer than the average; 296 remain to be accounted for, 93 of these pass the limit; they may have been watered, and, in fact, many probably have, but they are just above the limit; 203, or 67·9 per cent., are below the limit, and this represents the amount of sophistication I have actually found. The percentage of added water in these samples varies from 3 per cent., to 61 per cent. Out of the 300 samples no less than 63, or 20 per cent. of the total, are just on the limit line of solids (not fat) and fat in genuine milk. But as soon as this limit line is passed, watering goes on rapidly; 15 per cent. of the samples contain more than 20 and less than 30 per cent. of added water, and 15 per cent contain more than 30 per cent.; in all 68 per cent. were watered.

The percentage of skimming is almost equally formidable; here again I have passed all samples above the limit, though it is too low; but even on this low calculation 19 per cent. were skimmed as well as watered, and more than 7 per cent. were skimmed but not watered.

This tale of sophistication is really serious to the public. Averaging the 300 samples, the result is that 13 per cent. of the fat has been skimmed off, and that the milk has, in addition, been watered nearly 13 per cent.; while if the figures I actually found in the dairies are taken as the standard, as I consider they ought to be, 20 per cent. of the fat has been skimmed off, and the watering is 19 per cent.

Ten years' working of the anti-Adulteration Acts has brought us really to this point, that as regards milk our position is hopeless until the law is amended; no one can hope to get pure milk in London, unless under other guarantees than this Act affords, and we ought to tell the public so, that they may take action in the matter.

Trivial fines of a few shillings do not bear on the question at all. The average consumption of milk in the middle class districts of London may be taken at something like ten gallons per head per year, but to put it at the least I will take 3½ gallons per head per year as the average, or say 1½ oz. per day each person. The milk bill of this population of four-and-three-quarter millions must therefore be, at fivepence per quart, somewhat about £1,400,000, or seven-eighths of the water rates, which are £1,562,000.

This milk appears to be watered on the average nearly 19 per cent. The value of this milk replaced by water is £266,000 per year. It is not easy to say absolutely what value shall be given to the fat, but certainly it is putting the most lenient view possible on the matter if we consider that the abstraction of this fat is equal to a value of £90,000 more.

Adding this figure to the other, I find that we in London pay £356,000 a year for fraudulent dealing with milk—just about one-fifth part of our water rates. How long this will

be tolerated I cannot say, but it needs no calculation to show that the amount is enough to pay a profit to all the vendors concerned, if only it were fairly divided.

After this statement of what is actually being done at the present time in reference to the sale of impure milk, it will surprise no one if I say that I think further legislation is imperatively needed, not only to enforce the adoption of a somewhat more rigid standard, but to increase the efficiency of the supervision at present exercised over the milk supply; a very much larger number of samples should be examined, so that purchasers may procure something like a genuine article instead of an adulterated one.

I am not at all prepared to say that this will not be attended with an increased price in milk ; but that I look upon as a matter of trifling moment only, if the steps that are taken are such as to ensure an uniform and genuine article.

THE ENGLISH DAIRY.

BY

PROFESSOR J. P. SHELDON.

June 16th, 1884.

A LECTURE ON THE ENGLISH DAIRY.

By Professor J. P. SHELDON.

MR. H. M. JENKINS, Secretary to the Royal Agricultural Society, in the chair (in the unavoidable absence of the Earl of Aberdeen).

THE subject which I have to bring under your notice to-day does not require any introduction or apology on my part, because I find, in the Exhibition, the question of dairying has been very prettily, conveniently, and effectively displayed. Interested as I am in dairy farming, I have taken very great pleasure indeed in inspecting the model dairies to be seen on the left hand going down the main hall, which, no doubt, many of you have seen and admired the same as I have. The question, then, of dairying, important as it is to the nation at large, finds a proper place in an Exhibition of this description. Surely anything which has to do with health ought to find a very appropriate expression in matters relating to the dairy, from which we derive so much that contributes in the way of food to our health. We owe a great deal to the cow, a great deal more than we are in the habit of acknowledging, or even of thinking. Those of us who are familiar with the cow, who live in the country, and see her constantly, do

not think half enough of the benefits that she renders to us, and those of you who live in London and see cows very seldom, and when you do see them, see them only for a very short time, can scarcely be expected to think as highly of the cow as she really deserves. You must bear in mind that the cow is not only a benefactor to the human race, but she has also been a slave, and for these reasons I claim that cows ought to be treated by those who keep them with the greatest kindness and tenderness. The cow is rather a prosaic animal, and that is, perhaps, the reason why her praises have seldom been sung by poets, novelists and others, but we do find mention of her in some of our fine works, in George Eliot, for instance, and those who have read Adam Bede will remember the beautiful picture there drawn of Mrs. Poyser's dairy ; and Charles Dickens, sometime ago, said that if mankind were to return to the worship of animals, the cow would become the chief divinity, which was certainly very high praise for the cow.

Now the present aspect of dairy farming in England is, I am glad to say, better than it was a year ago. Dairy farming in England, in common with other kinds of farming, has suffered a good deal during the wet seasons which have been so general now for something like eight years. Of course it has suffered less than corn growing, and even less than sheep husbandry. If we compare the present position of dairy farmers with corn-growing farmers, and a great many sheep farmers also, I think we shall find the comparison is decidedly in favour of dairy farmers. The outlook, indeed, for corn growers in the British Islands is very gloomy. It has been impossible for them to pay their way of late years, simply because the seasons have not only prevented them from growing the crops they were aiming at, but prevented them from growing certain crops they might otherwise have done, and on the heavy wet soils of England we find the greatest depression has for some time past prevailed. This is owing almost entirely to wet and sunless seasons, but there are other things against which the agriculture of the British Islands has had to

contend of late years, viz., the low state of commerce and increased foreign competition. These things have come against farmers all at once, and it is not wonderful that there has been a time of depression in the agricultural world. One of the results of this series of wet seasons has been to diminish the number of cattle in the British Islands. The land has been unable to sustain the quantity of cattle that it did in years gone by. I know this from repeated observation, and from my own personal experience, that the land, however well it may have been kept in condition, has been unable to sustain, as it did some years ago, a given number of cattle that might be placed upon it. The cows, for instance, on pastures have given less milk, and the milk itself has been less rich in quality. The yield of cheese and butter derived by dairy farmers from their farms has been smaller, and in some respects inferior in quality, owing to these wet seasons. I find from the official Blue Books of the agricultural returns, that the number of cattle in the British Islands in 1874 was 10,281,036; last year the number was 10,097,943, showing a deficiency still of 184,093. The lowest point was reached in the year 1878, when the number had gone to 9,761,288. The increase in the number of cattle from the year 1878, when the lowest point was reached, to the number in 1883, that is in five years, was 336,655, which is very satisfactory, and it is more encouraging still to find that from the year 1882 to the year 1883 there was an increase of no less than 265,526 in the twelve months. I look forward, when the returns made a few weeks ago are published, to find that we have almost, if not quite, got back to the numbers that we had in 1874. What we want now is of course fine weather, for we have had a plethora of bad seasons. The land has been sodden and saturated with wet, and our fine old pastures, like unto which there are none anywhere else in the world that I have seen, of the best description, have languished from the superabundance of wet and the absence of sun, and the consequence has been that they consist to a large extent of inferior grasses whose nutritive properties

are smaller—grasses which are less attractive to cattle and less valuable in all respects.

Dairy farming as an industry is a most important one. The capital involved in dairy farming in the British Islands, speaking first of that of the tenant farmers, or at all events of the actual dairy farmers, whether they farm their own land or are tenant farmers—tenants' capital you may call it —is no less than from 175 to 200 millions sterling; and the capital belonging to the landlords is much larger than this, and would reach from 1300 to 1400 millions. So that taking them altogether there is a landlords' and tenants' farming capital in dairy farming alone pretty well equal to 1600 millions, or twice the amount of our National Debt. I think these figures will satisfy you that dairy farming, as an industry, is one of the most important we can possibly possess in a country like this.

Now "milk" is a word familiar to everyone. It is not an euphonious word, but the fluid which the word represents is a most valuable one. As an article of food milk is a necessity of life from youth up. There is no other article of food which will sustain life alone, without the assistance of any other kind of food, and for an indefinite period, but milk will do this. Milk possesses the various elements required for the nutrition of our systems in just the proper chemical and mechanical combinations which are necessary. There is the proper amount of moisture to start with, something like 87°, the proper amount of casein, of albuminoids and carbonaceous matters. Three pints of milk are equal to 1 lb. of beef, so that at that rate milk at 4*d.* a quart would be about the exact equivalent of beef at 6¼*d.* a lb., or if we take beef at 1*s.* 0½*d.* a lb., milk ought really to fetch 8*d.* a quart, if each was sold according to its intrinsic value. Then take cheese,—1 lb. of cheese and 1 lb. of bread together are equal to 2 lbs. of either beef or mutton without bone. One lb. of cheese will cost you about 7*d.*, and ½ lb. of bread less than 1*d.*, whereas 2 lbs. of beef or mutton without bone will cost you something like 1*s.* 6*d.* to 2*s.* So that you see the immense difference there is in favour of milk

at present prices, and in favour of cheese also as an article of food.

The consumption of milk in the British Islands is very small, much smaller than we should suppose it would be. It is very small even in country places. The average consumption of milk by the people inhabiting these islands is a little over 3 pints per person per week. The consumption of cheese is something like 4 oz. per person per week, and that of butter something like 3½ oz. These, of course, are only approximate figures, for it is impossible to arrive at any definite data with respect to the consumption of these articles, but we can do so approximately by knowing the number of cows we have, by estimating the quantity of milk they produce and also the quantity of butter, and by knowing, as we do, by the Government returns, the quantities of cheese and butter that are imported from foreign countries. I have been at considerable pains in ascertaining these matters, and the conclusion that I have arrived at is what I have just told you. The quantity of dairy products required to supply London is something prodigious. We will suppose that Londoners drink or otherwise consume half-a-pint of milk per day, and we will take it, which I believe is approximately true at all events, and very likely the figures are already realised, that the population within a radius of 15 miles of Charing Cross is about 5 millions. If these people consume half-a-pint each of milk per day, that would come to about 1,250,000 quarts, and if you value those at 5*d.* a quart, it comes to 26,000*l.*; so that, assuming the figures I have given are tolerably accurate, it takes 26,000*l.* a day to supply Londoners with milk, that is, people including those living in the parishes within 15 miles of Charing Cross. At the rate I have suggested the people eat cheese and butter also, the mean value of dairy products in those forms amounts to something like 45,000*l.* worth a day, or 16 millions a year. After all, this is no great amount, for if there are 5 millions of people it is only about 65*s.* each per annum, or about 15*d.* each per week. The sum in the aggregate looks enormous, but

when you come down to details it is easily made up without going to any great extravagance in the consumption of dairy products. To supply London with these dairy products, reckoning the cows give something like 440 or 450 gallons of milk per annum, it would take 800,000 cows.

I have maintained for a long time past that the best purpose to which you can put a cow is to get all the milk you can from her. We are not all vegetarians, and we are not all blue ribboners, but both these classes are very good friends to dairy farmers, because they aid very materially in the consumption of milk. Personally, I am not much inclined to be either a vegetarian or a blue ribboner, but still I hope their numbers will increase. Suppose you fatten a cow, intending to make beef of her, an ordinary cow will give you about 6 cwt. of beef, and then the cow is gone; but a good cow will give you 5 cwt. of cheese in a year, or 3 cwt. of butter, more or less, or she will give you from 40 to 60 cwts. of milk, and you have the cow left; whereas, if you fatten the cow for beef, the cow is gone. This looks to me very much like killing the goose that lays the golden eggs.

We inhabitants of Great Britain and Ireland have every reason to be proud of our different breeds of cattle, which are the envy and admiration of the world, and they are acquired now very extensively at very long prices to keep up the quality of cattle of other countries. America depends to a very great extent on English cattle of various breeds to keep up the quality of those which she has imported before. It appears to me, further, although on this point I should not like to express any definite or final opinion, that the climate and soil of America are not equal to keeping up the quality of these breeds of cattle as it can be kept up in the British Islands. In the British Islands, being surrounded by the sea, we have a most humid air; we have the best pastures, better than are to be found anywhere, we have a fairly genial climate, and all these things combine to make up the highest expression which nature and

art together have yet produced as to what a cow ought to be. Our shorthorns are as ubiquitous as the Englishman is; the shorthorn, in fact, seems to be the shadow of the Englishman, and to follow him wherever he goes. Then we have the Jerseys, those sweet, deer-like little creatures, elegant in form, gentle in disposition, owing to the kindly treatment to which they have been subjected for generations past, in whose nature kindness has already become inherent owing to this gentle treatment; and these Jerseys give the richest milk. Then we have the Ayrshires, Scotch cattle, also excellent as dairy cattle, doing well in cold climates, and on inferior soil, where most other breeds of cattle would do badly. Then we have the Herefords, capital beef-makers as they are, and the Devons, which give excellent milk. All of you are acquainted with Devonshire cream, and you cannot disassociate the idea of Devonshire cream from that of the Devonshire cattle that give it. Then we have the ancient Longhorns, that old quaint race which seems to have been useful in its day. I have a great affection for cows; I am very fond of animals of all kinds, but particularly cows, they are so useful; they are, if properly treated, so sympathetic, so responsive to kindness, that I feel a sort of respect for that mythical personage who is said to have kissed his cow. I do not know whether it was the same person who kissed the maid that milked the cow with the crumpled horn or not; it may be, but at all events if it was one and the same person, I think it was only polite that he should have kissed the maiden first.

With regard to the treatment of cattle, I place first and foremost the word kindness. It does not matter how well you feed cattle if you do not treat them with kindness in the way of handling—if you do not familiarise yourself with them. It is a very ungrateful sort of thing to feed these cattle well and then to thrash them, as I have seen some people do, in a fit of passion, when a cow would not stand quite still when she was to be milked. Cattle want treating with kindness and gentleness. I scarcely know to which the benefit chiefly falls, the giver or receiver of kind-

ness: it seems to react from the one who receives it to the one who gives it, so that, even from a selfish point of view, I would advocate those who have to do with cattle to treat them with kindness, because it will surely come back to themselves.

With regard to the feeding of cattle, one great principle to be kept in view is this, that when they are artificially fed in winter time, it should be with food that is in a state easily digestible. With regard to the question of ensilage, about which we have heard so much of late, I am not able to express a very definite opinion. My excellent friend, Mr. Jenkins, who has kindly taken the chair to-day, has been at great pains in collecting evidence upon it, but I think has not himself arrived at any definite or final conclusion. We have also the well-considered opinions of Dr. Voëlcker and Sir John Bennett Lawes, men who are an ornament and credit to this country, who have done immense service, not only to the agriculture of Great Britain, but to all the world. These gentlemen are not much in favour of it, but consider we ought to act with caution. Ensilage will be chiefly valuable as a food for dairy stock, if it becomes generally adopted in this country, because of its easily digestible condition. Now this is the state food ought to be in when it is fed to dairy cattle; not only does it relieve the cattle of a great deal of work in the digesting process, but the result in milk, in cheese, and in butter, will be much more satisfactory. There are various ways of preparing food in winter time—the hay, straw, and the like, together with the roots you grow, and the purchased foods of various kinds—in order to adapt them to the many wants of the animals, to make them more easily digestible, to make them the more assimilable by the animal system. Some years ago a Mr. Jonas, a large farmer in England, conceived the idea of improving the quality of his straw, or at least of placing it in a better shape as food for cattle, by the simple expedient of chaffing along with the straw something like 5 per cent. of green food, tares, or anything else that was green and succulent, then putting the

chaff, straw and green-stuff down together, along with a little salt. This was found, according to Dr. Voëlcker's analysis, to have resulted in a great improvement in the nutritive value of the straw and also in its digestibility, and the smaller proportion there was of undigestible fibre. This all goes to illustrate what I just now said, that the principle of giving to cattle food easily digestible is a most important one in the management of stock. Of course there is nothing superior to good grass, but we cannot have good grass all the year round. In winter time in this climate we have to provide an artificial supply of food for our cattle, and we must do so in the best way we possibly can with reference to our climate. If practice of ensilage should become common, that of course will relieve us of a great deal of difficulty and disappointment in respect to wet seasons, because we can then store our grass in a green succulent condition, containing all its moisture, and use it just when we like in that condition, but somewhat altered chemically in other respects. I knew a farmer of Derbyshire, some years ago, who was considered ahead of his day, and he, although the thing was not generally understood then, came to the conclusion that it was much better that his cattle should have food given them easily digestible, and instead of giving straw in the ordinary dry condition as it comes from the threshing-machine, he had it put into the open air, and let the rain fall upon it for a few days, or, if there was no rain, he would have water poured upon it, and let it stand and soak. This was found to soften the fibre of the straw, and to make it more assimilable and digestible. The result was his cattle throve upon it much better, and a smaller quantity was required to keep them in a fair condition; this was given along with other kinds of food which were necessary to supply the qualities in which the straw was deficient. In chaffing various kinds of food along with the straw, pulping roots and mixing these together along with purchased food, corn meal, and so on, let them lie for a time in a moist condition, during which a gentle fermentation sets up. This is a system which

increases the digestibility of the food, improves it and makes it more profitable to use. In summer time we cannot improve upon grass; we may add to it, but we cannot improve upon it. There is nothing equal to grass of good quality, to the fine pasturage which we have in most valleys of England, and on some of the table lands also. But you may add to it by giving the cattle some corn; and I have found for some time past that linseed cake and also cotton cake given to cattle with grass was a paying thing to do. A certain amount of food of that kind gives vigour to the cows, gives a stimulus to the frame of the animal, supports her under the arduous process of giving milk, and also enables your land to carry a greater stock, and improves the quality of your land. In fact, there is nothing better for good grass land than to consume upon it, with the stock you keep there, various kinds of purchased food, particularly cakes. Land naturally will decrease in quality if you constantly keep feeding cattle upon it, and do not return anything to it beyond the excreta of the animals. The bulk of the land in this kingdom will do so. There are some fine old pastures, of course, that have been pastures for generations, and have never required any additional help; but these are few and far between, the bulk of pastures requiring some assistance over and above all that; and if you wish to improve your grass land, and make it equal to carrying more stock, and to yield you a larger profit, there is no better way of doing it than consuming with your grass linseed and cotton cakes in equal quantities. Decorticated cotton cake I have found to be the best. There are also various kinds of meal, if you think proper, but the cake is perhaps the handiest thing you can use.

I should be very sorry to see these fine pastures of the British Isles broken up by the plough. I have a great respect for the old pastures we find in parts of England, Scotland, and Ireland, for some of the finest grass land in the world is to be found in some parts of Ireland. I have travelled myself over various countries, and over a good

deal of America and Canada, but I have never on the other side of the Atlantic seen a natural pasture or an artificial one which an English farmer would call first class, so that not only we have to be proud of the cattle we have in the British Islands, but also the land which sustains these cattle, of the herbage which grows upon it, and of the general excellence of everything with regard to dairy farming.

Now in France dairy farming is disconnected a great deal from grass land. My friend, Mr. Jenkins, in his reports in the Journal of the Royal Agricultural Society, has given very graphic descriptions of French dairying which are valuable to us, and he has told us that in some Departments of France the dairy cows scarcely ever go out to the pastures at all. All the lands, or nearly all, are kept under the plough, and various kinds of green crops are regularly grown and carried in to the cattle, and eaten in a yard or croft of some description, but the cattle themselves never go out grazing on the pastures as we so love to see them do in England. Now this question of arable *versus* grass land dairy farming is a very important one. It is evident that arable farming in England with respect to corn growing is destined to decrease even more than it has already done. The price at which we get wheat from America, from Russia, from India, and other countries too, is such that it is clear that no English farmers can grow corn and pay their way except on the best soils. Indeed, our great dependency in the East a few years ago sent us no appreciable quantity of wheat at all, now she is sending us an enormous quantity, and I think it very likely indeed that the effect of India on the wheat-growing farmers of the world will be quite as severely felt in America as it is likely to be in England. On a great many of the soils of America, those almost limitless prairies, any other mode of farming, except growing corn of one kind or another, is out of the question. In England, on the great bulk of our soils, we can turn our attention to something else. We have dairy farming, we have an unfailing demand for milk, for fresh

butter and the like, and the result must be in the future that a great many of our soils which have erstwhile been used for the growth of corn, of oats, wheat, and barley, must be devoted to a greater extent, if not entirely so, to the growth of green crops, roots, and so on, for the maintenance of herds of dairy cattle. This is a thing for which we ought to feel thankful, that a good deal of the soil is capable of being diverted to these other purposes, and I feel sure that in the future we shall find that it will be more and more turned into that channel. I am no advocate, and never have been, of what is known as high farming. It is only fit for men with very long purses, and cannot be held out as an example for the tenant farmers of England; but if you keep your land stirred about with the plough, and farm it just nicely, that is the thing to do, not to go to extremes either way—there is a happy mean which farmers ought to aim at, which will be productive of more profit by far than either extreme. Farming in this fashion, growing green crops either to be consumed as they are, or to be put into pits to make silage, seems to me to be one of the coming features of English farming on those soils which have been used almost entirely for the growth of corn with an occasional crop of roots. There is no doubt that land kept moving under the plough in this way will produce a much larger weight of food. If you let your land lie in grass, unless it is the very best of land, it will not produce the maximum quantity of food for stock, but if you stir it and keep it moving then it will. But then in the comparison of these two systems of grass land and arable land the question of profit arises; there is a good deal of expense always attaching to arable cultivation; you want horses, men, and so on, and the question arises—will the additional yield from the land under those circumstances pay for the additional expense? It seems to pay in France; dairying there in the arable districts is a very profitable and popular business, and if it is suitable to France, I scarcely see any very powerful reason why it should not be equally suitable to England. The chief difficulty to my mind is this, that

the French, I do not say that they are more industrious than the English, but they seem to me to attend more closely to the small details of their every-day practice, than is the custom with English farmers. We English, and I speak as an Englishman, and probably the same faults exist in me as in my fellow countrymen, are too much in the habit of lumping it together, roughing it so to speak; we do not seem to take such pride in minute details, in watching the little points connected with our practice. We seem in our farming to prefer getting over a good deal of country in a rather rough-and-ready sort of way, instead of getting over a smaller quantity of it, and doing it very neatly and very nicely. These remarks, of course, do not apply universally, but they apply generally, I believe, so far as my observation is concerned, to English customs as compared with customs in France.

Another matter in connection with dairy farming, apart from the treatment of the land, is the selection of the breed of cattle. I have a great respect for what is known as pedigree. I like a long ancestry. I think it is a very useful thing in itself, but I do not value it very much unless it is accompanied by achievements. What has been happily termed a "pedigree of achievements" is after all the most valuable pedigree we can possibly possess. That is what we want in dairy cattle: we want a race of dairy cattle descended from individuals which were famous as milkers. Our shorthorns one hundred years ago, when they first began to be famous under the hands of the brothers Collings, Bates, Booth and all those men, were known to be excellent milkers; but during the last fifty years they have fallen away a good deal from this reputation, that is, some families of our pedigree shorthorns have. Milking properties in a cow, as you will easily understand, are natural properties artificially developed. In a state of nature a cow would only give sufficient milk to rear her own offspring, but in a state of domestication, where cows are hand milked, and have been for generations, the production of milk in much larger quantities than is required for the rearing of

their own offspring is attainable, and becomes hereditary. Now in the finest pedigree cattle we have in these islands the most delightful to look upon, which are worth thousands of guineas perhaps, the question of the quantity of milk has been considered of very second-rate importance, and has been left out in the cold a good deal, and the result has been that these animals have fallen off in the quantity of milk they give until it has become quite hereditary with them to be unable to support their own offspring. That is what I should call pedigree apart from achievements. On the other hand, we have pedigree shorthorns which are still excellent milkers, and I say we ought to attend to this point, particularly in our dairy cattle.

Again, having considered the question of land and of cattle, we come to the question of the treatment of milk. Milk is a very delicate susceptible fluid, and requires to be treated in an intelligent sort of way. I have often noticed people milking cows in various parts of England with dirty hands, which is a most abominable practice. I consider that the udders of cows ought to be cleaned, if necessary, before they are milked, and it is the duty of the master to see that the people who milk his cows have clean hands before they go to work. It is no use attempting to make cheese or butter from milk that is dirty to begin with, and a great deal of milk is unfortunately dirty from the causes I have mentioned. Then as to the question of the grooming of cows, I should say that cleanliness is a capital thing. I am glad to find that the consumption of milk is increasing very rapidly in England. For many years past it has been the sheet anchor of English dairy farmers, and is likely in the future to be even more so. I hope it will continue going on, because, as I said before, milk is an extremely valuable article of food, and British dairy farmers would be very much obliged to you if you required an additional supply of it at their hands. From some foreign countries we can get cheese much cheaper than we can afford to make it in England. America can send us vast quantities of cheese, and also butter, and we can get cheese from various

countries on the continent of Europe, and from Canada, cheaper than we can afford to make it here, and therefore the milk trade is the thing that ought to be cultivated. In order to do this it is necessary that the Adulteration Act should be very strictly enforced, and people found adulterating milk with water, or anything which is less innocent than water, ought to be very severely proceeded against by the authorities. I am sure that if the public can depend on getting a genuine article in milk, they would consume more and more of it. Milk is so delicious, so generally excellent a thing in itself, that people only require to be able to get it pure to take an almost unlimited quantity of it.

With regard to cheese making, a question has been mooted, first of all I believe by my friend Mr. Jenkins, whether English farmers might not profitably go in more than they have yet attempted to do for making what are known as soft cheeses, which are so common on the continent. English cheese is known under the distinctive term of hard cheese, that is, cheese which is hard on the outside and which will keep for a considerable period. English cheeses as made on the old-fashioned principles, when made properly, are seldom fit to eat until they are twelve months old. I have a cheese in my house at present, made in June last year, and I do not intend to cut it for some time to come, because it is not yet ripe. That is hard cheese, but soft cheese, which is so common on the continent, is made for early consumption. It sells as a rule at higher prices than ours, and there is a larger product of it from a given quantity of milk, so that if our farmers should go in for making it, and there is a sufficient demand, no doubt greater profit would be the result. But after all the taste of the English cheese consumer is not at present sufficiently educated to require a very large quantity of this cheese. The question then of going on making hard cheese in England, or making soft cheese, is one which well merits attentive consideration at the hands of our dairy farmers, and I think to some extent we may with advantage go in

for it. I am able to say here that already, in fact for some years past, that famous cheese known as Gorgonzola, which is an Italian cheese, and which, in my opinion, stands next to our own Stilton—which is the finest cheese in the world—has been made with considerable success in Leicestershire. I have tasted it, and it is equal to the best Gorgonzola I ever tasted made in Italy, and if this can be made in England, surely French and Swiss cheeses are capable of being made, and they will, no doubt, if the public demand these cheeses, but until the demand is greater than it is at present I think it is, perhaps, not advisable that we should go in extensively for them.

There are two things to which I wish to allude for a moment or two, and then I have done—things against which dairy farmers have to contend. In the first place there are adulterated or imitation dairy goods, such as butterine, a great deal of which, I am sorry to say, is sold by dealers, who possess a very easy sort of virtue, for genuine butter. This sort of thing ought not to be allowed; I do not say for a moment that butterine ought not to be manufactured and sold as extensively as the public require, but I do mean to say that whenever a spurious article representing the genuine article, representing also an article so famous and excellent, which is in such demand, is made it ought to be sold under the name which properly designates it. There is no dairy farmer ready to find fault with people who make butterine, but he is ready to find fault with people who sell butterine for butter. It seems somewhat curious that these spurious articles should have had their origin in America, a country so remarkable for its magnificent natural capabilities that one would think they need not make anything by way of imitation; but this butterine, I believe, had its origin—certainly oleo-margarine cheese had its origin—in America. The Americans are not content with having the superabundance Nature has given to them, but seem to delight in deceiving their fellow creatures. We have heard of wooden nutmegs and also artificial eggs. It seems a strange thing to make artificial

eggs, but they do that in America. Surely one would have thought they could grow corn enough and rear hens enough to produce natural eggs, without making artificial ones; but in America those spurious dairy goods are made, and I am sorry to say that in England they are sold to a very great extent. In Holland there is a great deal of butterine made by those people, who are so wonderfully clean, and so famous for neatness and order. If making butterine extensively and sending it over as butter is the result of systematic cleanliness, I should rather prefer a little honest dirt.

Another thing the dairy farmer has to contend against is disease from foreign countries. This is a very serious drawback to dairy farmers, and I question whether it is sufficiently realised; at all events, where it happens it is more serious than are the wet seasons we have been going through of late years. There has been a great deal of controversy between the town and the country with respect to this disease question. In some places it is said the country want to go in for protection, and want to stop cattle coming in from the diseased countries in order to keep up the price. They do not wish to stop cattle coming over to England; what they wish to stop is the disease coming with these cattle. Mr. James Howard, Member of Parliament for Bedfordshire, a man who has been of great service indeed to British farmers in various ways, stated some time ago, as the result of a very careful investigation, that the diseases which we had imported from abroad had destroyed of our own flocks and herds a larger amount of flesh than we imported. This seems to me a very suicidal practice to follow, that we should allow cattle to come from foreign countries where they will not take the pains to stamp out these diseases, and bring with them the disease to invade our own flocks and herds. Keep out the disease; let the cattle come in if they will, but keep out the disease. We farmers are not anxious at all that foreign cattle should be kept out of the country, but what we want is to get the cattle unaccompanied by disease.

The CHAIRMAN, in proposing a vote of thanks to Professor Sheldon for his lecture, said he believed there was a very wide field opening in the future to English dairy farmers, not by way of substituting for their present practice that of foreign countries, but of engrafting some of those foreign practices on their own, as they found there was a market for those foreign products. He quite agreed with what Professor Sheldon said, and he would only add that to enable English farmers to make the best of their pastures and our wonderful breeds of cows, it was necessary that foreign diseases should be kept out, and agreed with him that, perhaps with some very small exceptions, British pastures could not be matched in the world, and certainly our breeds of cattle could not be found anywhere else ; but to make the most of the advantages given us by Nature and improved by art, farmers must be better instructed themselves, and must instruct those they employed better in the future than they had done in the past. Such an Exhibition, in which education was engrafted upon the subject of health, ought to convey a lesson to all that education must be looked to by Englishmen to enable them to do better than they had hitherto been enabled to do, especially in the face of growing foreign competition.

Mr. A. J. R. TRENDELL then proposed a vote of thanks to the Chairman, thanking him in the name of the Executive Council for so readily taking the chair at a moment's notice, in the unavoidable absence of Lord Aberdeen, and for the eminently practical remarks with which he had favoured the audience. This was carried unanimously, and the proceedings terminated.

THE DANISH DAIRY.

BY

ALEXANDER MARIBOE.

July 26th, 1884.

A LECTURE ON THE DANISH DAIRY.

By Alexander Mariboe.

His Excellency M. de Falbe (Danish Minister) in the chair.

The Chairman said he had much pleasure in introducing Mr. Mariboe, who proposed to give a lecture on the Dairy of Denmark, and he thought this subject had some claim to attention, partly because of the efforts which had been made for improving dairy management, which were supported by the Government, a great deal of money having been devoted to experiments of various kinds, so as to determine the best mode of producing dairy products, and it was thought that good results had been produced which must have been of value, not only there, but wherever similar manufactures were carried on.

LECTURE.

Mr. Chairman, Ladies and Gentlemen,—It is at the suggestion of an eminent authority on dairy matters, and a partner in the London and Provincial Dairy Company, (Mr. J. I. Watts), that I have the honour of addressing you on the subject of the Danish Dairy. But before commencing, I must crave your indulgence, not only for having

to read my paper, but for what errors in your language I may be guilty of making.

I propose to give you a short summary of the principles and methods adopted in our country in the management of milk and butter.

Our first attention is directed to the cow, the source and fountain to which we look for a rich and bountiful supply of milk, and one which is not likely to fail or disappoint us under judicious care and treatment.

In selecting cows for dairy purposes, it is not so much a matter of importance to fix on any particular breed, as to be careful that the individual animals chosen are in a vigorous, sound and thriving condition. There is often the greatest difference in the yield of milk given by different cows of the same breed. Although subjected to the same treatment and diet, some of the animals will yield as much as 600 gallons per annum, whilst others will not give more than 300 gallons. A dairy farmer should therefore understand first of all, how to choose animals best suited for his purposes, and this done, the rest remains in his own hands.

The exact result of each cow's yield is easily ascertained, by "trial-milking," on a certain day once a week the whole year round, and every dairyfarm in Denmark is provided with a book in which not only the yield is marked down but each cow is allotted a separate column, and its age, breed and pedigree entered, and the daily yield from the whole of the stock is also marked down, but by itself in a separate book.

Now, let it be remembered, the actual *quantity* of milk yielded by a cow is no absolute criterion of its value as a butter-yielder. The experiment of churning each cow's milk in a separate churn, has shown that cows which give a small yield in quantity of milk, often produce a larger proportion of butter than the copious milkers.

In Denmark there are three principal breeds. *First*, the *Angel* cow. She derives her name from *Angeln*—a part of *Schleswig*, and is considered the best *milch* cow. Her colour is red, without markings, and when pure bred, she

is conspicuously well formed for milking purposes. By intelligent care and better selected food, these animals have, through a series of generations, been brought to yield the maximum quantity of milk, whilst their physical development has likewise been improved.

Second, the *Funen* cow, so called after one of our islands. She is also red, sometimes marked, and appears to be a descendant of the Angel breed. She also is considered an excellent milker.

Third, the *Jutland* cow takes her name from the northern part of our peninsula. In colour she is black and white or dun and white. In shape and size she resembles the Angel cow, but is not so good a milker as the latter. She is to be found principally in the north-west part of Jutland, the climate and fodder of which she is better adapted to stand than the Angel cow.

It is often difficult to find a stock of perfectly vigorous and good milking animals, and as a rule it takes as much as four or five years (and sometimes even longer) to bring a stock of well selected Angel cows into good working order.

Now if we want our cows to treat *us* well, we must begin by doing the same to them. We all know how much a clean and comfortable and airy house, together with plenty of good and palatable victuals, contribute to our well-being and happiness, and in this respect we are in no way different from our friends the cows. In order that our cows may prosper, it is not only absolutely necessary that they should be kept clean in themselves, and well fed with a fodder specially selected with a view to producing the richest and best milk, but due regard must be paid to the warmth, and light, and ventilation of the buildings in which the cows are kept, and the importance of those cannot be too strongly emphasized. Moreover, everything should be so arranged in the byre, as to enable the herdsmen to do the necessary feeding, watering and cleansing with the minimum of labour, and the maximum of good result. All the new byres in Denmark are built on these principles, and many of them on a thorough and costly scale.

Particular attention is paid to temperature and ventilation, and every byre is provided with several thermometers, and the temperature regulated within certain unvarying degrees, by means of ventilators arranged overhead as a precaution against draughts. A special care and knowledge in the management of the ventilation and the regulation of the temperature is necessary if we wish to preserve a good coat on the animals, and this is of great importance in the spring when they are first put out to grass and exposed to chills. Against these, we also use the precaution of providing the cows with blankets, similar to horsecloths, which are strapped over them during the first weeks in spring when they are sent out to pastures during the day.

In order to produce milk and butter of the finest quality, the following are the most important matters to be considered.

Firstly, care as to the purity of the drinking water, and in the selection of fodder according to our experience and knowledge of its influence on the quantity and quality of the milk and butter.

Secondly, scrupulous cleanliness throughout in the management of the byre and of the dairy products.

Thirdly, skill and care in the manipulation of the milk and butter.

Too much attention cannot be paid to the purity of the drinking water. It is unnecessary for me to enlarge on the danger—and alas! the frequency—of wells from which cows are allowed to drink being poisoned by contact with drains, by stagnation and otherwise—a danger not affecting the cows only, but one most likely to spread epidemics amongst the consumers of their milk. I must also remind you of a minor danger connected with impure drinking water; namely, that it is apt to affect the flavour of the milk. I myself know an instance of a farmer who, in spite of every care and precaution lavished on his dairy, never could succeed in producing butter up to the standard at which every dairyman ought to aim. He searched in vain for the cause of this failure until by chance, the drains on his farm happening to want repair, the source of the evil was discovered.

A decomposed rabbit was found in the pipe through which the water flowed that the cows were in the habit of drinking. This had communicated the peculiar flavour to the milk, which had damaged the butter, although it did not visibly affect the health of the cows. Therefore, before passing on to the next point, let me again insist on the great importance of strict attention to the freshness and purity of the drinking water used on dairy farms.

With regard to the selection of fodder, a scientific knowledge of the proper proportions of fatty and farinaceous qualities of the food *should be* and on our large Danish estates *is* brought to bear on the matter. Too large a percentage of fatty matter yields a butter of so greasy a nature that it is impossible to handle it properly; on the other hand, too large a percentage of farinaceous food yields a butter too dry and brittle. In our dairies a strict diet is apportioned on these principles and administered in such a way that the animals' appetite is stimulated, whilst their ruminating and digestive organs are given the exact and necessary time for work and rest, which is so very important to a proper assimilation of their food, and which varies according to the different nature and quality of the particular fodder used in different parts.

I refrain from entering here into a detailed account of these points and of the *special* mixtures of fodder used; it would carry this paper beyond its prescribed limits. Suffice it to say that on our large farms the herdsman commences operations somewhere about five in the morning. The cows are milked, the fodder weighed out in its various proportions and carried in bags to the byre, the watering attended to, the cows and the stalls cleaned and the animals left in quiet and peace for the requisite time until the hour comes round again when operations have to be recommenced and wound up for the day, generally at about six or seven o'clock.

With regard to the feeding of the cattle in summer, opinions differ. A great deal has been said and written in favour of keeping the cows in the byre all the year round.

Many farmers adopt this plan on account of the saving of manure, but they forget that whilst they are gaining in *that* way, they are, by keeping the cows close—getting an inferior product of milk and butter; for even in the most perfectly organised byres the air and smell during the summer season is certain to exercise an injurious influence on the milk. After close observation and varied experience, my opinion is, that it is of infinite advantage to the cows that they should be sent out to the pastures in summer. The fresh air and the living grass are necessary for them and cannot be supplied with the same results in the byre, even when fed with green fodder.

We have two ways of treating cows on pasture in the summer, either by letting them free in the field, or by having them tethered. There are also differences of opinion on this subject, and after many discussions, in which much has been said for and against both methods, I believe it is a point which must be judged of and decided according to circumstances, and in our country, especially in regard to large stocks, the former method, in spite of many advantages, is not usually adopted.

With a small herd (say from eight to ten cows) together in a fenced field, where they have plenty to eat and drink, it will be only necessary to keep an eye on them now and then, because when the cows know each other (and they quickly make friends) they will be very quiet, and will not want even to overstep the boundary of their field, but content themselves within its limits for their grass. But in the case of a large drove of perhaps 80 or 100 or more head, it is a different matter. They must then be watched by a herdsman, who generally requires the assistance of a dog besides. The presence of this latter often has a disturbing influence on the cows, which is bad for them; moreover, in these large herds some of the members are almost sure to be ringleaders of mischief, and to tempt their companions astray; and just as one naughty schoolboy in a class is sometimes enough to disturb and distract the other would-be obedient and industrious scholars, so

even one refractory cow in a herd is liable to cause so much disturbance amongst the others, as to prevent their getting or taking their food and rest, as they ought to do, and when the milk-maids come to milk them at morning and evening, they have often great difficulty in driving them to a corner, and in keeping them quiet for the time. Besides that, these influences render the milk-maid's work more difficult; the cows being driven to milking necessitates the trampling down of a great deal of good grass, which is an important point to be remembered, and our principal reason why we prefer to tether the cows; for it is a well known fact that unless the grass is quite fresh and untrodden the cows will not eat it with the same relish.

We have two ways of tethering the cows. Either a tether of ten yards long may be used, in which case a cow gets more quickly over the field to be brought back again to where she first commenced; or a tether of five or six yards long may be used, and each time the cow is moved she is given the radius of fresh grass which is necessary for her until the next time of moving. By this latter plan, it takes a longer time before the cow has to be brought back to the same part of the field at which she commenced, and the grass has thus a better chance of being fresh and nice. Old and tall grass is not good for the animals. With either of the foregoing systems the cows have to be moved six or seven times a day.

Our mode of watering the cows is to carry the water to the field in a water cart with two wheels, and the cows are given to drink either out of a pail or from a small trough on wheels, which is drawn behind the cart. By driving between the rows two or three cows can drink at once. A good man with one horse should be able to water 100 cows twice in a day.

I have now tried to give you an outline of the treatment of our cows on dairy farms in Denmark. I shall now proceed to describe the milking system. As I have already urged, the utmost care must be had with regard to cleanness in all the milking arrangements, without which all

our other work in connection with butter making is more or less in vain.

In the first place the cows' udders are carefully and gently washed—in winter with tepid water—and the milk-maid's hands carefully washed and dried, after every second cow she milks. When the milk is poured from the milk-maid's pail into the large milk cans, used for transporting it to the dairy, it is passed through a *special* kind of fine sieve or strainer, which prevents the finest hair or grit from getting into the milk. As soon as one of these cans is full it is carried away to the dairy, where, after it has been weighed or measured, it is put into milk pans or coolers, according to the different systems used for creaming. We make it a point to carry away the large milk cans from the byre or field as soon as they are full, for in the byre the milk is apt to become tasted from the smell of the air, and in the field we wish to protect it from the heat of the sun, for which purpose our waggons used for conveying it to the dairy are during the summer covered with canvas awnings.

As a rule, on our large farms we have an overseer to superintend the milking and the maids. His duty is to see that the latter pay the necessary attention to the washing of the cows' udders and their own hands during the whole process, and to be careful that the very last drop of milk is drained from each cow's udder, for not only is that the richest of the milk, but otherwise the udder is likely to get into an unhealthy condition. If it should happen, from such neglect, that a cow's udder should become affected, great care must be taken not to mix its milk with the milk from sound udders. Care should also be taken not to mix or use for any dairy purpose the *biestings* (or first milk from the cows after calving) which, in my opinion, is good and necessary for, and should always be given to the calves themselves.

Before bidding good-bye to our milk-maids, let me remind you of one of the special duties which we call upon her to perform in a most thorough manner, namely, the

daily scouring of her pails and milk cans. This must be done with boiling water and soda and with plenty of cold, clean water to rinse them before setting to dry for the morrow's use, so that her pails, as *she* herself, may be a type of all that is wholesome and fresh.

Now it is well known that Denmark takes the lead as an authority on dairy matters. They are the principal resource of our country, and with the help of our largely increased grants from Government, for purposes of scientific experiments, and investigations of the various systems, carried out by different practical men on the largest estates in the different parts of the country, our dairies have attained to a wonderful degree of perfection.

You will gain some idea of our advance and increase in these matters when I tell you that our first grant from Government, which was given in 1876, amounted to £100. Since then it has been continued annually, and in 1880 amounted to no less than £1200. This amount, for our little country a large sum, has been used for scientific investigations and experiments on dairy systems. The first impulse given to these came from one of our most energetic landed proprietors, who, at that time, was president of the Royal Agricultural Society, and took a great and intelligent interest in dairy matters.

The first experiments were commenced about the year 1875, and were directed to ascertaining the best methods of getting and using ice or snow for dairy purposes, and of erecting ice-houses on the best principles for its preservation during the warmest season. Later on, these experiments led to a series of valuable results, not only as to the best methods of setting up the milk, but also as to the varying qualities of the milk at different seasons of the year. Formerly, the usual mode of setting up the milk had been after the Holstein system, in wooden bowls about eight inches high. These were set on the brick or cemented floors of the milk cellars and allowed to stand from 24 to 36 hours before being skimmed. It was by that time more or less sour, according to the weather, and this

condition was detrimental to the keeping quality of the butter to be made from it.

The important points to be discovered therefore, were how to keep the milk fresh and also to enable the cream to rise in the shortest time. For this purpose the next system tried was that of coolers; and this plan was adopted from Sweden and called the *Schwartz* method, after the inventor. It consisted in having the floors of the milk cellars arranged with a series of trenches. These were about three feet in breadth by two and a-half feet in depth, and ran from one end of the cellar to the other at distances of about three feet from each other, and with a margin at the ends and sides (of course) for walking round. They were made (like the cellar floor) of brick and cemented, and a flow of fresh cold water was led into them, which escaped at the other side and was kept at a certain level by means of waste holes along the sides. Into this running water the tin milk coolers were placed. This plan was a decided improvement on the old system of wooden bowls, but yet a further improvement was soon to be applied, and it was found that the use of ice round the coolers gave not only a larger quantity of butter but likewise improved it in quality. Wooden boxes, lined with tin, are now recommended in preference to the brick trenches as causing less melting of the ice.

I have only now to mention the latest and best invention of all: namely the separators, by means of which almost every particle of cream is separated from the milk immediately it comes from the cow.

With all these different systems to choose from it becomes a matter for the dairyman to know which is the best and most profitable from every point of view. It is a well-known fact that milk is a fluid which varies in quality and behaviour under varying seasons and circumstances, and this being so, experiments have shown that it is often advisable to adopt different systems of setting and cooling the milk according to the season of the year.

As I have already mentioned, it is of great importance to

have the milk set in the dairies as quickly as possible; for, besides that it ought to be removed at once from the smell of the byre, or from exposure to the sun in the field, it is necessary, in order to get the best rise of cream, that the milk should be set to cool whilst it is as nearly as possible the temperature at which it is taken from the cow; namely, 104° Fahrenheit.

Care must also be used in setting the milk in the cellars, to have the windows always open during the first two hours, so that the vapour rising from the milk may be carried off.

When the system is used, of setting the milk in coolers plunged in fine crushed ice, the most profitable size of coolers to use are those which contain about 30 lbs. of milk. These are provided at the bottom with a rim of iron, three or four inches deep, so that the ice gets at the whole of the under-surface of the coolers as well as round the sides, and the milk is thus cooled very rapidly. Indeed, this system is called "*rapid ice cooling*" for within two hours the milk is cooled down from 90° to 50°. Now after the milk has been set in this way for from 8 to 10 hours, our plan is to skim the top of the cream, which by that time has risen, and which may be literally described as "*the cream of cream.*" This is churned by itself, not only because it takes a shorter time to churn than when mixed with the thinner cream, but because it gives the very finest "extra quality" of keeping butter.

After this first skimming, the milk is allowed to stand for 10 or 12 hours longer, when it is skimmed a second time and the cream used for a separate churning. What cream still remains on the milk is used with advantage for the cheese.

Now, before entering into the subject of separators, I must say a word about the milk itself, and try to explain, as shortly as possible, something of the differing qualities and conditions of milk under varying circumstances and at various seasons.

First, then, we have the "*normal milk,*" by which I mean

milk in its best or ordinary condition, in which state the cream will rise freely and completely in from 10 to 34 hours, according to the system used.

Next, we have milk we call "*heavy*," because the cream in this case rises very sluggishly and imperfectly, so imperfectly indeed, that when it is in this state it is advisable always to use separators for extracting the cream, or where that may not be possible, the old system of wooden bowls will be found the best. Milk may become "*heavy*" from two causes: first, from the condition of the cow, after it has been in milk for from five to six months: secondly, from too long a time having been allowed to elapse between the milking and the setting to cool. The cream seems then to become fixed in the milk and refuses to rise freely, unless it be again warmed up to its normal temperature (104°) before being set to cool in ice or otherwise. It is easy to know when the milk is heavy from either of these causes, by the absence of any sharply defined limit between the milk and the cream after it had stood. Moreover, the cream will be poor and the skimmed milk richer-looking than usual.

The difference between the yield of butter from "*normal milk*" set in ice from 10 to 34 hours, and "*heavy milk*" treated in the same way, will be from 10 to 15 per cent., and sometimes even more.

Well, to return to our separators! A centrifugal skimming machine or separator, consists of a cylindrical pan (revolving on its own axis), driven at a high speed. This pan, which is enclosed in a cast-iron cylinder as a protector, is partially covered on the top, and has one large central hole, or several small ones, through which the milk is poured, and the skim milk and cream drawn off at a different part. When filled with milk this pan is driven at a rate of from 1,000 to 2,000, and in the case of De Laval's machine, 6,000 revolutions per minute. By the centrifugal force the milk is thrown from the centre against the sides, so that it stands like a perpendicular wall of milk inside the pan. The skim milk, as being the heavier fluid, is

thrown to the farthest side; the cream keeps to the inner side. The best separators, and those most universally adopted in Denmark, are those invented by Nielsen and Petersen, De Lavals and Lefeldts, and all working on the same principle. By keeping a constant supply of milk flowing into the separator, and at the same time drawing off the skimmed milk and cream in their due proportions, the machine is kept continuously working.

In Denmark, ice is now acknowledged as a *sine quâ non* for cooling milk, and even with our separators the use of ice for cooling off the cream is found necessary.

And now, finally, we come to the actual making of the butter. There are two different kinds of butter produced in Denmark; the "*sweet cream butter*" and the "*sour cream butter*." The former is specially made and packed in tins for export to the tropics. The latter is generally packed in wooden casks, and is principally exported to this country; though within the last six or seven years it has also been packed in tins and exported on a large scale to all parts of the world. The nature of the "*sweet cream butter*" explains itself from its name; the cream from which it is made being preserved in its original sweetness by the different methods which I have been trying to describe to you.

The "*sour cream butter*" is either made from cream which has been soured naturally by standing for a lengthened time on the milk, or artificially by being first cooled off and then warmed up to a certain degree, when it is poured into a barrel lined with tin, and covered outside with matting stuffed with seaweed for the purpose of maintaining an equal temperature. It takes from 12 to 15 hours to sour cream in this way, and the butter made from it is the very best that can be produced for keeping.

The churns generally used in Denmark are made of oak, shaped round and broadening towards the bottom. The cover is provided with a hole for the thermometer, and the speed is regulated according to the size. The smaller the churn, the greater the speed required. Great regularity of

speed is also requisite, and on all our largest estates steam is now more generally used than horse-power.

The temperature of the cream for churning must also be strictly regulated within certain degrees. The cream therefore, according to the different kind of butter to be made, must be either heated up or cooled off and the churn well rinsed with water, cold or tepid, according to the season and the temperature of the air. With due attention to these points, the butter should be formed in the churn in from 25 to 35 minutes.

Sometimes it will be found necessary to colour the butter, especially during winter, when the cows are fed with artificial fodder. The quantity of colouring matter to be used depends of course on the richness of the cream; but, as a rule, about ½ an ounce of butter-colouring to 40 lbs. of cream, will be found a good proportion during the winter season when the cream is pale. The colouring must be put into the churn along with the cream, so that it may become thoroughly worked into it.

It is also a point of importance to know exactly the right moment at which the butter is ready, and the churn to be stopped, and this we do when we find the butter-milk to be clear and the butter formed into small globules about the size of a pin's head. If the working of the churn should be continued after this stage, the result will be that the best particles of the butter will get mixed with the butter-milk and become more or less impossible to handle.

The butter, then, being properly ready, is caught in a fine haircloth sieve, and when the surplus butter-milk is drained off, the butter is taken up and carefully kneeded with the hand in order to squeeze out the remainder of the butter-milk. These pieces are then placed in the bottom of a trough and salt worked into them, after which they are taken from the trough and placed on spars fitted into a wooden box, which is covered with a tin cover, on the top of which ice is put in the summer, for the purpose of firming the butter. After remaining here for from one to two hours, it is put into the butter worker or kneading

machine, and subjected to the final process before being packed into the casks ready for the market.

And now Mr. Chairman, Ladies and Gentlemen, having finished our tour round the farm, and through the dairy, and having made a somewhat minute inspection of all the working details thereof, from the chewing of the cud onward to the branding of the butter casks, I have now only to thank you for the patience with which you have accompanied me thus far, and to recommend you to test for yourselves the efficiency of our dairy systems by the excellence of their produce.

The CHAIRMAN in proposing a vote of thanks to Mr. Mariboe, said he was not sufficiently learned in these matters to enter very much into details, but he had not seen several of the things mentioned by Mr. Mariboe in use in this country, and probably they might be introduced with advantage; at any rate it was perfectly clear that if the people of Denmark had attained a considerable degree of excellence in their dairy products, it was to a great extent because they worked on principle, and were ready to adopt the results of science as bearing on their particular industry.

Mr. WATTS moved a vote of thanks to the Chairman which concluded the proceedings.

DAIRY MANAGEMENT.

BY

MISS SMITHARD.

June 12th, 1884.

A LECTURE ON DAIRY MANAGEMENT.

By Miss Smithard.

Lord Reay took the chair, and briefly introduced Miss Smithard.

My Lord, Ladies and Gentlemen, I have been requested by the Committee of this Exhibition to give you a demonstration of making butter, with a few hints on the management of a dairy. I shall not commence with the feeding of cows and attending to them in the cow-house, though I once heard a very clever lecture given on cookery by Mr. Buckmaster, who said that cookery did not commence in the kitchen with the food, but that it commenced in the scullery with the pots and pans; and so I might say dairy work does not exactly commence in the dairy with the pans of milk and cream, it commences in the cow-house, with the cows, and the way in which they are fed. We will assume that the cows have been properly attended to, good food given them, and proper and clean water above all things; which a great many of you know better how to enter into than I can tell you. I shall commence with the dairy. Now I have found, very much to my surprise, that many dairies in England, and especially in the North where they profess to be such good dairy people instead of being built in the best part of the farm, have been built in the very worst. I could relate to you instances of

farms where they are built with a simple brick wall between the dairy and the piggeries. Now you all know that nothing taints so soon as milk or cream, and that bad drains should be kept away from a dairy or milk house. A dairy should be thoroughly well ventilated; and many farmers' wives have an idea that it should always be kept wet; but it should always be perfectly dry.

I will tell you why it should not be wet. You know that all water, however pure it may be, becomes stagnant in time, and if the dairy floor is wet, and the wet or moisture gets into the chinks it becomes in a very little time contaminated, and that contaminates the milk and cream. You cannot possibly keep a dairy too clean, too dry, too well ventilated, or too far away from very bad drains. Many old-fashioned dairies have what they call settles or shelves built always on brick work. I once saw one of those old settles taken down, and I can assure you they have only to be known to be avoided. That old settle was next to a wall where the pig-stye was. The farmer's wife said she thought no one could have a cleaner dairy than hers, but she never could have good butter, what was the reason? That was one of the reasons. There are many reasons for bad butter; one is that, in skimming the milk, the dairy-maid is too careful, I may say she wants to make as much of the cream as she possibly can, and the consequence is that she takes off a deal of the milk with it, and the milk goes quite tainted in a little time and spoils the cream. Suppose you churn only once a week, any milk that is taken off with the cream in skimming must become tainted before the week is out. Again, dairy-maids, especially when they have to market the butter, are very fond of leaving the cream on the milk too long, that is as bad a fault as the former one. When milk is set in the pan it ought to remain only a certain time. There are many systems of setting milk, there is the flat system, the Swartz system, of setting the pan in a tub of ice at a temperature of under 30°, and milk separators. I must say I like separators, for a large farm that will pay for a separator,

if not then I should adopt the flat system of setting milk, which is like you see here. I should also adopt these white porcelain vessels, they are so beautifully clean, you can see a speck of dirt on them ; they will bear scalding, although some persons would not think so. Then instead of having these settles I have spoken of, the best thing is to have a rotatory or cast-iron milk-stand. They are well ventilated, they are very portable, you can place them in any part of the dairy you like, so that you can make the most of your room. You can place them quite in a corner, and they are so constructed that you need not walk round to skim the milk ; you simply turn it round gently and bring the pan to you.

Now, I will show you what I mean by skimming milk. Of course a dairy in a room like this is not like my own little Warwick farm dairy in the Exhibition. If I could have brought that in here I should have been better able to demonstrate the proper way, but I will do what I can under the circumstances. When milk is drawn from the cow it is much too hot to be set, even in the pan. It should go through a refrigerator and be lowered 6° or 8°. On such a day as this milk from the cow would be 70°, and it ought to be about 64° or 65° to be set in pans. Then that milk is settled in the pan for 12 hours. For skimming you should then take the skimmer, and I advise the use of these porcelain skimmers for small dairies or private families. Everything is so clean, you cannot hide any dirt even if you be an untidy dairymaid. In tin pans, you know, there are joints, and however particular a dairymaid may be there may be something where the tin is joined which you do not know anything of, or do not see, and it may be, that it would taint the milk, and you would never know what was the cause of your bad butter. The milk when set ought to stand twelve hours, and at the end of that time you skim it, and put it in a creampot, No. 1. When you are going to skim, run your finger outside the vessel, this prevents a good deal of waste. If you do not do it, a thick cream sticks to the vessel,

and then you lose it; take your skimmer and skim it very carefully. This milk has not been set up many hours, and it ought not to be skimmed at all, but I will just show you how it is done. Do not be too greedy; it is much better to leave a little cream on the milk than to take one drop of milk off with the cream.

Then I should let this milk stand twelve hours longer and skim again, and should have a cream pot, No. 2, and skim it into it. Do not put the two creams together. To-morrow you might skim again. For private use I should take the cream of the cream, as I call it, of No. 1, and churn that for the use of the table. The second skimmings I should churn for house use; but if you are going to market your butter, the best way is to put the two creams together at churning time, but not before. Now, I cannot explain to you the system of skimming by centrifugal action with a de Laval separator, but it is very simple. The milk brought from the cow is put through a refrigerator and cooled a little, and then it is lifted into a cistern, and from the cistern we draw it from a tap into a strainer, from the strainer the milk falls into a machine, which has a cup in the centre; this cup rotates at the rate of 6000 or 7000 times per minute with the Laval system. It rotates so quickly that the cream being the lightest comes to the top; it is sent up the sides of the vessel into a tap or tube prepared for it. The milk being the heaviest falls to the bottom of the vessel, and comes out through another tube prepared for it.

Now we have come to the creams, I must tell you that by this time all requisites for dairy use should be thoroughly well cleansed. Cleanliness being one of the great essentials for good butter making.

It is not the only essential, for I consider honesty is required very much in butter making. You often find when people make butter for market they mix a lot of water with it, to make it weigh heavier, but it is not right, and not only that, it is not good for the butter. If milk or water is left in the butter it becomes tainted immediately.

Now, supposing we have prepared churns for churning; we take the churns, butter-workers and everything, and scald from 5 to 7 minutes; then rinse them out with cold water, and drain the cold water thoroughly away, because that water becomes very warm in time. Then wash them again in 2 or 3 cold waters until they are quite cold. Then we put the cream into the churn, and test it with a thermometer. Many dairymaids make a great mistake about testing the cream. I have been in several dairies lately and cannot make them test their cream, yet they come to me and complain, "What is the reason I cannot get my butter? I have been churning all day, and the butter will not come." The reason is because they will not take the trouble to test it, and bring it to the proper temperature, or they would have no difficulty whatever in making their butter. The cream should not be under 58 or over 60°. On such a day as this I should have it 58° or not much above it, because cream always rises in temperature a little in churning, perhaps 2°, and therefore it is better to have it at a lower temperature than a high one. When you have tested your cream, if not hot enough or cold enough we have these small cylindrical boxes; they are used because there should be no sudden temperature brought near the cream, either hot or cold, that would spoil the butter. If your cream is too hot fill one of these cylinders with ice, and just dip it in the churn for a few minutes, and it will bring the cream to the proper temperature. Do not leave it until it is so. If the cream is too cold fill the cylinder with boiling water, and then act in the same way the right temperature. Then we commence churning. Many people have an idea that the quicker the butter comes the better it is. But that is another mistaken idea. Butter is never good that comes quickly. I do not like butter to come much under 25 or 30 minutes. If it comes quicker you lose a percentage of butter, and you also spoil the nature of the butter. You cannot be too careful over these details. The first 5 or 7 minutes you are churning ventilate the churn well, that is take out the peg to let out

all the air. If you do not do that the air mixes with the cream, and it becomes simply a whipped cream, the churn fills with gas, and the dasher has no chance whatever to act, if there is a dasher in the churn; in fact the cream goes to sleep. We churn until the butter begins to break. After it begins to break we then churn slowly until it comes. Now, here is another great mistake dairymaids make, and that is, they go on churning as soon as they find the butter comes; they churn and keep on with it until they get the butter all in a lump in the churn; they will not adopt new systems as long as they can get rid of the butter. It is a well-known fact that foreign markets are beating us all out of our market, because dairymaids will not take a little more trouble. Butter-making of all things should never be hurried, and if you hurry it you will never have good butter to send to market. When the butter begins to break you should churn very slowly until it is formed in small globules. As soon as the butter is formed the churn should be stopped, and the butter-milk drawn off. That is the most difficult part of churning. I may as well say now that this is the Continental system, the system that is mostly adopted in Normandy. (You all know that the Normandy butter at this time fetches the best price in both the English and Paris markets, but there is no reason whatever why we should not have as good butter as they have in Normandy.) During this process of butter making, I shall not at all touch it with the hand, though I am not against touching it with the hand; but in summer time, on such a day as this, the greatest difficulty is to keep your butter cool enough to make up, whereas in winter time, the greatest difficulty is to keep it soft enough to make up, so that I should advise in winter time adopting the Danish system; that is, they use the hand. All cream is better ripened before it is used. By using ripened cream you get four or five per cent. more butter than with sweet cream, although, of course, sweet cream produces the most delicate kind of butter. The Danish system is this: They churn

generally in what is called a Holstein churn, an upright churn with a dasher which rotates at the rate of 120 times a minute; that is very different to our English churns, which are only supposed to rotate fifty or sixty times a minute. In Denmark, as soon as the butter has come, they immediately stop churning and do not throw away the butter milk; they take a hair-sieve, and put it in the churn and take up about two pounds of butter at a time. They shake the butter milk from it, and then place it on a wooden tub, or anything they can work it upon, and go on with that until they have the whole of the butter taken out of the churn away from the butter milk. The dairymaid then prepares her hands for touching the butter, because they work mostly with the hand, and a little with the butter-worker. We will suppose her hands are quite clean; in the first place she takes a damp cloth, and well wipes them. Then she dips them in boiling water, after that she plunges them in ice, and again washes them with a little butter milk that has been taken out of the churn for the purpose. Her hands are then prepared for butter, and no butter will stick to them. Then she takes up these rolls of butter, about two pounds at a time, and laying one hand over the other carefully presses out all the butter milk. She rolls that butter again endways, and presses it out again, and then she lays that piece of butter aside, and leaves all the rest in the same way, and each piece of butter will be rolled at least seven times. So that, you see, is rather a slow process. I am afraid many of our English dairymaids would not be troubled to do it, but it repays them in the end. She then takes up the butter and lays it on the butter worker, sprinkles it with dry salt, about four per cent., then she takes a butter knife to cut it, lays one piece over another, and works it three or four times through the worker. It is then put in pots ready for export, for most of it is exported to India. (That is the way good keeping butter is made.) Going back to the Normandy system, as soon as the butter milk has been drawn away from the churn, we then wash the

butter thoroughly well in at least four waters or until nothing but clean pure water runs from the butter. We then carefully take it out of the churn, and put it in the butter worker which has been already prepared for it, and work it through the worker, taking care not to work it too roughly, because we should spoil the grain, and when once the grain of the butter is spoilt, nothing will restore it. We cannot be too careful in handling butter, the more carefully it is handled the better the butter will be, and although this butter I am making to night has no salt in it, I will guarantee it will be very good keeping butter, although it is what we call sweet butter. A great many dairymaids cannot make sweet butter. Theirs will be sweet on the day it is made, but it goes quite rancid the day afterwards; that is because, as I have told you, of these bad smells, bad drains, bad skimming and bad management in the dairy. After the dairy requisites have been used they should be thoroughly well washed with cold water. (A dairymaid asked me the other day what was the reason I washed the churn in cold water first, she had never heard such a thing before, she always put warm water into her churns to begin with.) My reasons for washing the churns and other requisites with cold water is this. You must know that however sweet butter-milk is, there always is an amount of acidity in it; and if you wash your dairy requisites well with this cold water first, it washes away most of this acidity, but if you put boiling water into them it makes the acidity permeate the whole of the wood-work, and the consequence is they are never what you may call sweet. After having thoroughly well washed them with cold water we then scald them and use a very soft brush (because a hard brush spoils the grain of the wood-work). Everything that appertains to the churn and to the dairy ought to be very hard wood, and if we use a small soft brush you will not hurt them. They should be well brushed in boiling water and then rinsed in two or three cold waters. Then they should be placed in a nice cold place to dry, taking care not to put them in the hot sun, because if they are the heat

of the sun warps them very much. No soap or soda should be used anywhere, nor with anything that appertains to a dairy. If the dairymaid has an idea that there is a little grease or butter on the churn the best thing she can use is a little rough salt. She may dip her soft brush in it and brush the churn with that, and that is far better than using soda or soap, or anything of that kind. I can only tell you again that one of the greatest secrets of good butter is cleanliness, and I am sure if the dairymaid is not thoroughly clean she will never succeed.

After the butter has been worked we place it in the Danish hardening-box; these have not been much adopted in England yet, but one or two large dairies have adopted them, and they are very useful. They stand a little distance from the ground and are very simple in construction. It is a simple box with a few holes bored in the bottom to insure thorough ventilation. Round the bottom of the box there is a ridge of wood about two inches thick, and on the ridge slats are placed across-wise a little distance from each other so that plenty of air can get up between them. At the top there is a tray which holds ice which cools the butter naturally. If you put a lump of ice on to butter it will become hard, but the moment it comes into a warm room it becomes oil, and nothing will remove the oily substance afterwards; the butter is completely spoilt. It should neither lie in ice nor water; but ice at the top of the hardening-box keeps the butter cool naturally. Many people have asked me what they must do in the country where they could not get ice. My answer is, have a tray so constructed that you may place it under a stream of water with a tap at each end so that the water may be made to run gently into the tray, the tap at the other end being for waste. Of course the water can be utilised afterwards if it is required. These are the most useful articles in a dairy, because in the hottest weather you can insure nice solid butter. After it has been in the hardening-box from one to four hours we bring it again and work it through the worker, and it is then ready for

the market, or if it is found too soft we put it again in the hardening-box for a longer time. If you have not a hardening-box the next best thing to do with it is to wrap it in a nice piece of clean muslin and set in some cold place, but do not set it in water or let ice touch it. One of the greatest secrets of good butter making is to take care of it when it is butter, and to be careful not to spoil the grain of it. I object very much to salted butter, because I often find that salt makes butter very streaky and discolors it. Good fresh butter always commands the best price, especially in London. Then again, in making it up always take care that everything you use is quite wet, never attempt to make it up with anything, that is dairy knives, or beaters, or boards, or anything of that kind unless it is so. Of course it should be made pleasing to the sight. I once heard a great man say that everything in the way of food should first please the eye, then the nose, and then the mouth!

The best thing to wrap it in is paper prepared for the purpose, so that the grease will not go through it, but if you are going to pack butter for sending it away, the best thing is to make it up in small pats, roll it in paper, and have ready the box, which should be thoroughly lined with paper first, then some nice pieces of prepared buttered muslin; they should be well scalded and afterwards rinsed in several cold waters. The box should be well lined with this butter muslin, and then the pats placed in the box carefully, so that they shall not rub each other. In winter time there is great difficulty in getting the butter soft enough to work. It would not do to use these hard beaters, because it would work all the goodness out of the butter and spoil the grain of it. The hand, being more elastic, brings the butter to a proper consistency without using so much of this hard work, that is why I would use the hand in winter. If there is an objection to the hand, and of course it is porous, there is nothing so nice as to use wood for making up butter. A great many dairymaids say they have always managed to make their butter

it has always gone to market, and it has sold, and they did not see why it should alter it at all. Certainly their butter would not keep, but they do not mind that. But it is a fact that they do not sell such good butter in the English markets as we get from abroad, which is rather a disgrace with English dairy farmers. We have the finest pastures in the world, and the finest breeds of cows, and yet we get butter better from abroad than we have in England, and it fetches a better price. I went to visit a dairy lately, and the farmer's wife said that she had the best butter in the market. I went into the dairy, and it smelt rather strong, I looked up and down but could see nothing; I said, "The dairy does not smell sweet, are you sure you have very good butter?" "Well," she said, "I get a very ready sale for my butter." I said, "Will it keep?" she said, "Oh, it will keep a week, well," but when I came to look into it there was a large cupboard at the end of the dairy, or safe; in that safe was a piece of cheese which they kept locked up, a piece of bacon, and several other matters. She said, we always keep our best things in the dairy, the dairy is the place for them because it is cool; and so I found that when they baked bread, the bread was always taken to the dairy to get cool, because it was a cool place, and if they boiled a ham or anything of that kind, it was taken into the dairy to cool, and thus her bad butter was easily accounted for. I must advise all those interested in dairy work to have nothing in the dairy but what appertains to it—milk, cream or butter. A gentleman asked me one day if I thought it would hurt to hang a joint of meat in the dairy; I say decidedly yes, because a joint very soon becomes tainted, especially this weather, and of course it would taint the cream. You cannot be too careful to have everything that belongs to it perfectly sweet. Another hint with regard to dairymaids, always see that they have short finger nails. If you keep the finger nails short they are easily brushed, and there is no excuse for having dirty finger nails. I have said nothing about colouring butter, because I do not like coloured butter. It ought

not to be coloured with annatto. Water will not blend with grease, and, therefore, if you colour butter with annatto, which has a great deal of water in it, the butter will be quite streaky. There is a preparation of annatto with some fatty substance which I have heard of, but I have not seen it, which may be better. But of course to suit the public taste the butter has to be coloured by some dealers; and if you must colour butter I think the best way is to pulp some carrots, and strain this pulp through a fine piece of muslin into the cream before you begin to churn.

[The churning process having been completed by this time, Miss Smithard showed the manner in which it was taken from the churn and passed through the butter worker.]

In conclusion, I have only to say that if every detail is followed out that I have given this afternoon in the management of a dairy and in butter making, there is no reason whatever why English dairy farmers should not produce the best butter in the world. Last year, when at York, I had some butter which was kept six weeks and was perfectly sweet.

The CHAIRMAN, in proposing a vote of thanks to Miss Smithard, said they had had a most interesting lecture, and he entirely endorsed the observation, that there was no earthly reason why foreign butter should be imported into England, and why we should not make our own butter as good and better than Normandy and Danish butter. In the present distressed state of English agriculture he believed the English farmer had no better friend than Miss Smithard, and he could only hope that her lectures there and elsewhere, especially in the rural districts in the north and in Scotland, would tend to diminish the imports of foreign butter and to increase the home consumption of English butter, and if possible to increase its manufacture to such an extent that instead of importing foreign butter the English might be exported.

THE ÆSTHETICAL USE OF WINE

AND ITS

INFLUENCE UPON HEALTH.

BY

J. L. W. THUDICHUM, M.D., F.R.C.P. LOND.
PRESIDENT OF THE WEST LONDON MEDICO-CHIRURGICAL SOCIETY, ETC.

JUNE 11TH, 1884.

A LECTURE ON THE ÆSTHETICAL USE OF WINE AND ITS INFLUENCE UPON HEALTH.

By J. L. W. THUDICHUM, M.D., F.R.C.P. LOND.,
President of the West London Medico-Chirurgical Society, etc.

> " Pour forth, Muses, to me, the cheerfully sonorous voices,
> From Helikonian lips of song the melodious showers,
> For to whom-ever spends drink the source effervescent with music,
> Joyfully listens to words of happiness sung to the lyre."

IN adopting this hexametric invocation of the epic poet Nestor, of Laranda in Lykia, of the time of the emperor Severus, I desire at once to define the standpoint from which I intend to treat the subject of the æsthetical use of wine and its influence upon health. To my mind æsthesia is correct feeling, such as enables us to have the natural desires, the true physiological senses of pleasure and displeasure, and also the power of their correct gratification, by which the whole of organic life exists and is perpetuated. In many minds this feeling exists in its most perfect form as a natural gift apparently, but is no doubt the result of atavistic education, or of the collective influence of the good and happy lives of their forefathers through many ages. In other minds, however, who have not had similar advantages, this feeling is subdued, clouded, or even overcome by coarser motives, and of their possessors it may be said that they are victims of two contending desires, of which one only is æsthetic, while the other arises from ignorance of true pleasure, or from a delusion of the mind

regarding the sources and nature of true pleasure. This condition has a complete remedy in education, the application of the mind to the study of things and ideas. Such study leads to science in its widest sense, as a corrector and regulator of feeling. In this connection science includes poetry; for poetry is really the manifestation by highly gifted individuals of the fullest knowledge of that store of thought and feeling which we call the human heart, and the expression of that thought and feeling in forms so beautiful and true that they excite permanent pleasure and settled assent. Aesthesia is therefore, practically, a compound faculty, of natural organisation, of inherited structure, aided by science as a substance and refined by poetry as a form.

In order to understand aesthesia thoroughly, we may consider its negation or exaggeration. The term anaesthesia is no longer available for purposes of general definition, as it is exclusively applied to a state of physical insensibility, produced by medical art for special purposes, namely, for enabling sufferers from mechanical injuries or painful diseases to undergo operations necessary for their recovery, without that suffering of pain and shock, which, in times gone by was so great an addition to the original calamity. We must therefore be satisfied with describing the absence of the true aesthetical feeling by a longer negative than the convenient alpha privativum of the Greek language. But its opposite, namely an exaggerated sensibility to impressions, we may still describe as hyperaesthesia, and with the aid of these definitions we may now come closer to our subject than we could have done without them.

Alcohol is essentially an anaesthetic. It is taken in many forms for counteracting mere bodily pain, and does so counteract it. But it has collateral effects which make it undesirable for the production of higher degrees of anaesthesia. Physicians, therefore, take derivates of alcohol, more or less closely related to it, in a chemical sense, but all directly derived from it, such as ether, and chloroform,

to produce a quick and perfect insensibility. But these pharmaceutical preparations are not adjuvants of that euphoria which is valued in common life. Ether is dangerously inflammable, chloroform sickening; neither are agreeable in any form to a natural taste. They have in no case the effect of natural alcohol, such as is present in wine, of influencing the physical heart, and the imagination, so as to remove the actual sense of pain, the algesia, arising from physical fatigue, or from mental depression.

We have indeed a very powerful antidote to the hyperaesthesia produced by the friction of life in that remarkable compound termed beer. This drink contains relatively little alcohol, less indeed than other forms of alcoholic drinks, of which it is, therefore, generally the weakest, so called. But it contains a powerful anaesthetic in the form of the extract of hops, or lupulin, a principle which in Europe takes the same place as that which opium takes among eastern nations. Hops, like the poppy, stimulate at first the nervous energies of various departments of the system, but in larger doses they act as a sedative, and dull anomalous as well as normal sensibilities. Beer is, therefore, by no means an alcoholic beverage merely, and on that account admits of no direct comparison with wine or diluted spirits.

Alcoholic drinks, amongst them foremost wine, have effects which have caused them to be used and praised by all nations and generations of which we have any knowledge. They can be used with results which are the reverse of aesthetical; and it is to discountenance such abuse, injurious to health, and detrimental to pleasure, that all sanitarians should raise their voice. Of all alcoholic drinks, however, true wine, such as we shall define it, offers the least opportunity or inducement to abuse. Natural wine may make drunk, but it never produces delirium tremens, it never produces those permanent lesions of the tissues which are the consequences of excess in the use of spirits and of beer. Whenever such effects are added as the results of wine, they will be found to be due to wine

plus spirit added thereto, particularly to those fiery mixtures which under the names of sherry and port have done so much to obscure the real and beneficial qualities of wine.

Happily, after many centuries of fiscal misgovernment, which has perverted the natural taste and habits of the people of these islands, we have been allowed to return to a state of liberty as regards the choice of our wines, and the effect of this liberty has been most marvellous. The brandied wines, which were formerly almost the only ones which could be obtained or were drunk in Society, have been recognised to be incompatible with the more refined manners of our social gatherings, and, are so much neglected by the wealthy classes that the customs revenue from them has decreased by £300,000 a year. The natural wines have increased in favour, though, owing to unfavourable years, not to the same amount as the others have diminished. There are, however, indications to show that the intention of the legislature as manifested in 1858 is being realised, and it is my intention to aid now and in the future in this realisation, as I have done in the past.

But let us look for a moment at the origin of wine in nature, its history and preparation. This will enable us better to appreciate its importance to Society, and the danger of its counterfeits. I quote some passages from the Handbook on Alcoholic Drinks, which I was honoured with the commission to write for this Health Exhibition, and which I hope will soon be available to the public.

The vine grows naturally in the temperate parts of Western Asia, the south of Europe, Algeria and Morocco. In Armenia, and to the south of the Caucasus and the Caspian Sea, it exhibits its quality as a creeper, and rises up high trees, bearing fruit without being either cut or otherwise tended. It grows vigorously in ancient Bactriana, in Affghanistan and Badackshan, and in Cashmir. I have studied it in the Algaida, a forest situated on the south bank of the Guadalquivir, to the east of San Lucar de Barrameda. This forest consists mainly of sea-pines (*Pinus*

maritima), but contains also groups of the silvery elm. Almost its entire border, and many small and large open spaces in its interior, are lined with the wild vines first described by Clemente. I found vines covering the whole of large fir-trees, silver elms, oleander bushes, fig-trees, and, together with sarsaparilla in blossom and brambles, creeping up and covering shrubs of lentiscus. These garañonas, as the Spaniards term the wild vines, are really indigenous wild plants, and not stray children of the vineyard; for all the flowers which I observed had the *stamina recurvata*, which are the characteristic feature of the female type of the *diœcic* wild vine, and no erect stamina. I observed myself, in 1871, the place described by Clemente, where "the vines form impenetrable thickets, magnificent banqueting halls, most graceful pavilions, grottoes, covered walks, winding foot-paths, labyrinths, walls, arches, pillars, and a thousand original and indescribable caprices." The wild grapes here are black, acidulous, but good to eat. The growth of the plant is so vigorous that a one-year's shoot, which I pulled from a tree, measured fifty feet in length.

That the vine lived in Europe in the tertiary period is proved by the evidence of fossils. That it was present in pre-historic times is shown by the occurrence of preserved parts of the plant in various situations. Thus vine seeds have been found in the remains of the lake dwellings of Castione, near Parma, under conditions which show that they belong to the bronze age, at least 9000 years before our time; other lake dwellings, such as those at Varese, in the province of Como, and at Wangen in Switzerland, exhibit similar proofs. Near Montpellier, vine leaves were found in tufas, which, like those of Meyrargue, in the Provence, are pre-historic, but post-tertiary.

A. de Candolle is of opinion that the idea of producing grape-juice and allowing it to ferment might have originated with different nations, particularly in Western Asia, where the vine abounded, and grew well. It is unquestionable that the Semites, as well as the Aryans, knew wine long before historic periods, and were in a position to introduce

it into all the countries to which they migrated, including Egypt, India, and Europe. They could do this the easier as they found the vine wild in several of the countries in which they arrived. As regards Egypt, we have documentary evidence that the cultivation of the vine and the making of wine were practised nearly six thousand years ago, namely under Phtah-Hotep, who lived at Memphis four thousand years before our era. The progress of the cultivation of the vine by Phœnicians, Greeks, and Romans, is well known. A. de Candolle says that towards the east of Asia it seems to have advanced so slowly, that the Chinese do not seem to have cultivated the vine before A.D. 122, although several varieties of wild vines are known to occur in their northern provinces. This is, however, at variance with the statement of Welles Williams, according to whom the first cultivation of the vine in China is ascribed to Foh-hi, a ruler estimated to have lived about three thousand years before the Christian era. It is further recorded that about 1120 B.C. wine was considered in the celestial empire to be dangerous to the state.

The Accadian or Chaldaean epic poem, which describes the adventures of Nimrod, brings him to Hasisatra—the Noah of the Israelites. The latter in the course of the account which he gives to Nimrod of his salvation from the flood, also gives details of the manner in which he provisioned his ship, the ark. Six thousand men carried provisions in six thousand baskets; he took on board also wine, much wine, aye rivers of wine. This emphasis, which I quote by memory from the translation of George Smith of the cuneiform inscribed tablets from the library of Assurbanipal at Nimrod, now in the British Museum, shows us that wine was known and highly valued under such depressing circumstances as the prospect of an aquatic voyage for which Hasisatra prepared, and which he endured.

It is not necessary for our present purpose to investigate the particular steps in the progress of the human intelligence, by which wine, such as we know it now, was discovered

The shepherds of the Algaida gather the wild grapes in earthenware pots, and bury them in the ground under leaves and brushwood, and later on drink the fermented juice at their leisure. From such an original proceeding to the confection of Burgundy or of Champagne there are many stages, to describe which would lead us too far. We will therefore pass at once to a description of wine such as can be given by abbreviated science.

Wine is the fermented, purified, and ripened juice of the grape; as such it contains alcohol, acids, salts, extractives, and those principles which give to it its particular colour on the one hand, and its particular flavour, smell, or bouquet on the other. While some of the ingredients can be accurately described and isolated, others are accessible to a definition by the sense of smell only. The conventional value of wine is determined less by its principal ingredients than by the prominence of the specific character termed bouquet, and the absence of certain faults. Dietetically, most wines are of equal value, provided they are the products of a favourable season, are pure, and free from the faults produced by parasitic fungi.

The principal alcohol in wine is alcohol strictly so called, or spirit of wine, the chemical composition of which is expressed by the formula C_2H_6O. In rare cases there is some butylic alcohol, $C_4H_{10}O$, and in others some amylic alcohol, $C_5H_{12}O$, so-called fusel oil, present. The quantity of alcohol present in wine can be estimated by distillation, and ascertaining the amount of spirit in the distillate by the determination of its specific gravity, or by ascertaining the specific gravity of the wine, then driving away all spirit from it, and having again brought it to its original bulk by the addition of water, ascertaining its specific gravity without the spirit. Other methods are less accurate. The quantity of alcohol present in natural wines from the grape varies between 6 and 12 per cent. Unsound wines may contain some aldehyde, C_2H_4O, produced from alcohol by the loss of hydrogen.

The acids present in wine are those naturally present

in the grape, namely tartaric, malic and tannic; and those produced during fermentation, namely acetic, formic, succinic, and carbonic. In addition to these there are nearly always traces of the more complicated fatty acids, such as propionic, butyric, and œnanthic acid present. Tartaric acid, $C_4H_6O_6$, occurs in must as acid potassium salt, or so-called tartar, and is in part precipitated during fermentation, as it is less soluble in spirit than in water. During the ripening of wine, tartaric acid forms with alcohol tartaric ether. The tartaric acid most commonly found in wine turns the plane of polarised light to the right, and is therefore called dextro-tartaric acid. Some wines, however, *e.g.*, Italian, contain also tartaric acid, which polarises to the left, levo-tartaric acid, always, however, combined with the dextro-tartaric acid, forming what is known in science as racemic acid. All three acids have one and the same chemical composition expressed by the formula $C_4H_6O_6$. Sherries contain no tartaric acid, as it is removed from the must of Jerez grapes by gypsum or plaster of Paris.

Malic acid, $C_4H_6O_5$, is not only present in grape-must, but in the juices of many varieties of fruit, which we shall have to consider—apples, cherries, plums, currants, and the red berries of the mountain ash.

Tannic acid is present in most varieties of wine, and is derived from the husks and kernels mainly; more rarely contained in the juice of the grape. Red wines contain more of it than white wines, because they are always fermented with the husks and seeds.

Succinic acid, $C_4H_6O_4$, in wine is one of the results of the fermentation of grape-sugar, which, in that process yields about half a per cent. of its weight of that acid. When the formulæ of succinic, malic, and tartaric acid are compared, it will be perceived that they all contain the same number of atoms of carbon and hydrogen, but not of oxygen, of which latter element succinic acid contains four, malic acid five, tartaric acid six atoms.

Acetic acid, $C_2H_4O_2$, occurs in wine and other fermented

liquids, principally as the result of the oxydation under the influence of the air, of some alcohol. When the entire amount of alcohol in a fermented liquid is transformed into acetic acid, vinegar results. Vinegar from wine preserves some of the flavour of wine, and those accustomed to its use are therefore not inclined to exchange it for the more common vinegar made from fermented malt, or from acetic acid obtained by the fiery decomposition of wood. In good natural wine the amount of acetic acid does not exceed 1·78 per thousand, but is ordinarily only about half a pro mille; in spoiled wine its amount may rise to 3·63 per thousand.

The œnanthic acid, to the ethylic ether of which most wines are supposed to be indebted for their characteristic smell, has the formula $C_{14}H_{26}O_3$, and does, therefore, probably not belong to the same series of acids as acetic, propionic, and butyric acid.

In good, sound wines the total amount of free acid varies between 0·3 and 0·7 per cent; wines with more than the latter amount of free acid taste excessively sour, and are not easily digested.

The ethers in wine are aceto-ethylic, which contributes much to the general flavour of the wine; aceto-propylic, butylic, amylic, caproylic; further butyro-ethylic, caprylo-ethylic, capro-ethylic, and pelargo-ethylic, and the tartaric ethers. The characteristic smell of the œnanthic ether distinguishes all kinds of wine from every other fermented liquid. The flavour or bouquet, however, by which wines from different vines and vineyards are distinguishable from each other, is produced by substances which are already present in the grapes, and the effect of which is only heightened by fermentation. The volatile ethers in wine mostly surmount the fixed ethers in quantity. The alcohol obtained by the decomposition of all the ethers is rarely more than 0·06 per cent of the wine.

Wines may contain more or less of sugar of one kind or another. Must contains a mixture of sugars, of which one polarises to the right, and is therefore termed dextrose,

while the other polarises to the left, and is in consequence termed levulose. If wine contains cane-sugar, it has been added, *e.g.*, to champagne. Even added cane-sugar is, under the influence of the natural acidity of the wine, gradually transformed into the mixture of dextrose and levulose, this mixture also goes by the name of invert-sugar. Some wines, *e.g.*, Sauternes and old sweet Rhine wines, contain also a peculiar sugar, occurring in flesh and brain, namely, inosite. All sugars in must and wine have the chemical composition expressed by the formula $C_6H_{12}O_6$, but differ in properties. They are, therefore, not identical, but, as it is termed, isomeric with each other.

Another sweet-tasting substance occurring in wine and all other fermented liquids is glycerine, $C_3H_8O_3$, originally known as one of the constituents of animal and vegetable fats. During fermentation it is formed from sugar; 100 parts of cane-sugar, or 105·26 parts of grape-sugar, yield on an average 3·69 parts of glycerine, or one-fourteenth part of the alcohol produced by the same fermentation.

The colouring matters of wines are either natural constituents of the grape, or produced in must and wine during and after fermentation. Of the latter kind are most yellow and amber colours of natural so-called white wine. They are not rarely the result of the oxydation of astringent or tannic acids. But the red colouring matters are mostly contained in the husks, and dissolved only by the concurrence of the alcohol formed during fermentation and the acid naturally contained in it. The grapes from which some of the best red wines, *e.g.*, Burgundy or Médoc wines are made, yield an almost perfectly colourless juice if pressed before fermentation. But some rarer vines, and those yielding inferior wine, have, like the black currant, a coloured juice. Some of the red colouring matters contain iron as an essential chemical ingredient, and are therefore supposed to make the wines in which they are contained particularly wholesome.

Wine contains traces of ammonia, present in all vegetable juices; also albuminous matters, which are supposed

to make the wine liable to undergo decomposition more readily. Wine also contains some substances, which remain when it is evaporated to dryness, and are termed extractives. They have an agreeable smell and taste, and contribute to the smell and taste of wine in the same manner as the extractives of meat contribute to the smell and taste of meat and broth. Wine further contains a certain amount of inorganic or mineral ingredients, potash soda, lime, magnesia, and phosphoric, sulphuric and hydrochloric acid in combination with the former. Sherries contain a large excess of sulphate of potassium, due to the treatment of the must with plaster of Paris.

Wine may be aesthetical wherever grown or made, provided only that it be free from faults of manufacture and the destructive fermentations called diseases. These latter fermentations are the main cause, while better methods remain unpractised, of the addition of spirit to the wines of southern climates. All former ages have abhorred strong wines, and the ancients mixed some of theirs with water. In the last century yet natural wine was esteemed, spirited wine denounced in this country.

I quote, after the late Dr. Druitt, some passages from Armstrong's 'Art of Health,' written about a hundred and fifty years ago, which are supposed to show how much Burgundy and other natural wines were esteemed at that time. When speaking of wholesome wine, he praises

> "The gay, serene, good-natured Burgundy,
> Or the fresh fragrant vintage of the Rhine."

He further describes Burgundy as the drink for gentlemen, and Port as an abomination :—

> "The man to well-bred Burgundy brought up,
> Will start the smack of Methuen in the cup."

The last line refers to the Port wine imported into England under the Methuen treaty made with Portugal in 1703 whereby the wines of the latter country were favoured by a low import duty, whereas the trade in French wines was

impeded by an import tax amounting to more than double of that imposed upon Peninsular wines.

Armstrong already reprobates the mixing of wine with brandy, which seems to have been at his time, if not a new, at least a newly-revived practice. In describing a man's sensations on awakening after having drunk Port wine the evening before, he says :—

"You curse the sluggish Port, you curse the wretch,
The felon, with unnatural mixture first
Who dared to violate the virgin wine."

We can easily learn the aesthetical uses of wine from the poets of all ages, beginning with him, however, who has most endeared himself to thinking men.

In his ode to Septimius (Od. II. 6). Horace alludes to Tarentine wine, growing on the hill Aulon, near Tarentum.

"There Jove accords a lengthened spring,
And winter's wanting winter's sting,
And sunny Aulon's broad incline,
Such mettle put into the wine,
Its clusters need not envy those,
Which fiery Falernum grows."

The Romans affected handsome or important slaves to pour out their wine for them. Horace asks Iccius (Od I. 29) if it be true that he grudges the Arabs their wealth, and is actually forging fetters for the hitherto invincible Sabaean monarchs, and those terrible Medians ? To which of the royal damsels does he intend to throw the handkerchief, having first cut down her princely betrothed in single combat ? Or what young "oiled and curled" Oriental prince is for the future to pour out his wine for him ? Iccius (says Theodore Martin) like many another Raleigh, went out to gather wool and came back shorn.

In his Ode to Pompejus Varus (Od. II. 7), who had been a fellow-student with Horace at Athens, and had fought with him at Philippi under Pompey, the poet describes more fully the use which he and his friends made of wine on joyous occasions, such as was the return of Varus (Martin, 136).

"Then pay to Jove the feasts that are his fee,
And stretch at ease these war-worn limbs of thine,
Beneath my laurels' shade; nor spare the wine,
Which I have treasured through long years for thee.

"Pour till it touch the shining goblet's rim,
Care-drowning Massic; let rich ointments flow,
From amplest conchs! No measure we shall know.
What! shall we wreaths of oozy parsley trim,

"Or simple myrtle? Whom will Venus send
To rule our revel? Wild my draughts shall be,
As Thracian Bacchanals! For 'tis sweet to me
To lose my wits, when I regain my friend."

Even when praising measured enjoyment of the fortunes of life, he does not forget wine, as in his Ode to Dellius (Od. II. 3).

"Where the tall spreading pine
And white-leaved poplar grows,"

splendid description of a southern forest! the mixture of the sea-pine, and the alamo of the Spaniards,—

"And, mingling their broad boughs in leafy twine,
A grateful shadow throw,
Where down its broken bed the wimpling stream,
Writhes on its sinuous way with many a quivering gleam.

"There wine, there perfumes bring,
Bring garlands of the rose,
Fair and too short-lived daughter of the spring,
While youth's bright current flows
Within thy veins, ere yet has come the hour,
When the dread Sisters Three shall clutch thee in their power."

The poet also depicts a state of melancholy, when

"neither marbles from the Phrygian mine,
Nor star-bright robes of purple and of pall,
Nor the Falernian vine,
Nor costliest balsams, fetched from farthest Ind,
Can soothe the restless mind."

In his Ode against false prognostications (Od. I. 11) he warns the reader not "to wrest a false assurance from Chaldaean horoscope," but gives the positive advice: (Martin, 151):

"Be wise, your spirit firing
With cups of tempered wine,
And hopes afar aspiring,
In compass brief confine.
Use all life's powers;
The envious hours
Fly as we talk; then live to-day:
Nor fondly to to-morrow trust more than you must or may."

In the Ode to Sestius (Od. I. 4), the gloom of Orcus is made the back ground, on which to depict life, all fresh, joyous, luxuriant and lovely! Be happy "drink in at every pore the spirit of the season," while the roses are fresh within your hair, and the wine-cup flashes ruby in your hand (Martin) for—

"Thee soon shall night enshroud, and the Manes' phantom crowd,
And the starveling hours unbeautiful of Pluto shut thee in;
And thou shalt not banish care by the ruddy wine-cup there,
Nor woo the gentle Lycidas, whom all are mad to win."

The statesman fatigued with the cares of his office, Maecenas, he addresses thus (Od. IV. 9):

"Thou dost devise with sleepless zeal,
What course may best the state beseem,
And fearful for the city's weal,
Weighst anxiously each hostile scheme,
That may be hatching far away,
In Scythia, India, or Cathay."
(Martin, 158.)

But he urges him to escape from town for a few days:

"Scion of Tuscan Kings, in store
I've laid a cask of mellow wine,
That never has been broached before.
I've roses too, for wreaths to twine,
And Nubian nut, that for thy hair
An oil shall yield, of fragrance rare."

Martin relates that Maecenas was of a melancholy temperament, and liable to great depression of spirits. On his first appearance in the theatre after one of those dangerous attacks of fever to which he was liable, he was received with vehement cheers, and to mark the event the

Poet laid up in his cellar a jar of Sabine wine, and some years afterwards he invites Maecenas to come and partake of it (Od. I. 20). From this we learn incidentally that it was not all '*grand vin*' (as the French term the best quality), what Poets did drink at Rome (Martin, 161).

"Our common Sabine wine shall be
The only drink I'll give to thee,
In modest goblets, too;
'Twas stored in crock of Grecian delf,
Dear Knight Mæcenas, by myself,
That very day when through
The theatre thy plaudits rang.
Old Caecuban, the very best,
And juice in vats Calenian pressed,
You drink at home, I know:
My cup no choice Falernian fills,
Nor unto them do Formiae's hills
Impart a tempered glow."

Julianus of Egypt had, some short time before the Emperor Theodosius the Great, composed many graceful poems, of which only fragments have been preserved. One, entitled 'The Swallowed Eros,' I translate from the Greek Anthology of my father, Dr. George Thudichum. Vol. viii. p. 1066.

"When lately twining garlands,
From freshly gathered roses,
I found a lovely Eros;
I took him by his winglets,
And dipped him in my wine-cup,
And drank him down entire.
Now ever since that moment,
He scrabbles in my inside."

The fragment thus leaves the poet in a not uncommon dilemma, and suggests caution in similar emergencies. At all events poetic souls should think of an antidote to such intoxication, before they expose their hearts to the risks of similar unhappiness. Perhaps Zerlina could help them, who in her aria 'Batti! Batti!' also avows the scrabbling of Eros, but says that she can cure it:

"I know a remedy,
Tender and sure."

This aria, with Mozartian music, seems to me a perfect cure in itself. However, Egypt no less than Spain prizes wine, and even the Moslems, to whom wine is forbidden by the book of Mahomet, drink Champagne, as not subject to the interdict. The Shah of Persia, however, when in this country was a complete abstainer, or at least entirely disdained brandy and soda-water. The proper use of wine suggests ideas; some admit that the ideas are only more rapidly evolved with the aid of wine, and not increased in number or scope; as it is practically expressed, a wine drinker thinks quicker, but not better, with the aid of wine. The quicker flow of ideas facilitates their communication, and thus wine aids in animating conversation. It is also believed by authors of many ages, that the effect of wine is antagonistic to hypocrisy and untruthfulness, and that under its influence men lay aside their mental masks, and show their actual features, an effect which the Latins described in the saying, "In vino veritas!"

As we are internationally assembled—although the representatives of foreign nations may be conspicuous by their absence—it is perhaps not inappropriate for me to allude to some other praises of the aesthetic uses of wine, which have been propounded in different tongues.

There are those beautiful verses, breathing Horatian inspiration, Latin, statuesque, humorous:

> "Mihi est propositum in taberna mori,
> Vinum sit appositum morientis ori,
> Ut dicant cum venerint angelorum chori,
> Deus sit propitius huic potatori."

Here the very angels are to intercede for the deceased oenophilist.

Another breathes the tender melancholy of a solitary man—a poet, forsooth—who has got, as Artemus Ward would term it, "into the sere and yeller leaf," and does not like it. He feels with the Chorus in Sophocles' Oedipus in Kolonos:

> "When manhood has left him, alone he stands and powerless,
> Every disgrace he must suffer."

This is his monologue, appropriate to be sung on a moonlit evening, with flauto obbligato.

> "Lauriger Horatius, quam dixisti verum,
> Fugit Euro citius tempus edax rerum.
> Ubi sunt nunc pocula, dulciora melle,
> Rixae pax et oscula rubentis puellae.
> Crescit uva molliter et puella crescit,
> Sed poeta turpiter sitiens canescit.
> Quid juvat eternitas nominis, amare
> Nisi terrae filias licet et potare."

The Greek poets, epic and lyric, are the great examples of enthusiasm for good wine. Thus sang Homer nearly 3,000 years ago, in the ninth book of the Odyssey, describing the beneficence of Maron, the minister of Apollo: remember of Apollo, our special patron, the healing God.

> "He fetched me gifts of various excellence,
> Seven talents of fine gold; a book all framed
> Of massy silver; but his gift most famed
> Was twelve great vessels, filled with such rich wine,
> As was incorruptible and divine.
> He kept it as his jewel, which none knew
> But he himself, his wife, and he that drew.
> It was so strong, that never any filled
> A cup, when that was but by drops instilled,
> And drunk it off, but 'twas before allayed
> With twenty parts in water; yet so swayed
> The spirit of that little, that the whole
> A sacred odour breathed about the bowl;
> Had you the odour smelled and scent it cast,
> It would have vexed you to forbear the taste;
> But then, the taste gained, the spirit it brought,
> To dare things high, set up on end my thought."

This is quoted by Mr. T. G. Shaw, in his beautiful work on wine, from the translation of the Odyssey by George Chapman, 1609. It was this wine which prepared Polyphemos for the loss of his eye, and thus helped to liberate Odysseus from the grasp of the fabulous cannibal.

The lyric poetry of Anacreon is to Greek literature what that of Horace is to Roman. Thus in the nineteenth Ode he sings:

> Ἡ γῆ μέλαινα πίνει,
> Πίνει δὲ δένδρε' αὐτήν.

Πίνει θάλασσ' ἀναύρους,
'Ο δ' ἥλιος θάλασσαν,
Τὸν δ' ἥλιον σελήνη.
Τί μοι μαχεσθ', ἑταιροι
Καυτῷ θέλοντι πίνειν;

The ancients knew no temperance or total abstinence societies, and practised no rivalry as to the wines of different countries. But the modern, or so-called cultured nations, have altered that. Thus our French neighbours, of whom Julian the Apostate said yet that they were poor in vines, and that their beer smelt of the he-goat and not of Bacchus, now are quite convinced that their wines are superior to any other in the world. Champagne comes in for the highest praise from the pen of Amaury de Cazanove, who however exhibits his limited taste by denouncing Bordeaux as a wine for old and decrepit people.

"Que le vieillard cherche un reste de vie,
Dans le Bordeaux qui réchauffe les sens,
Pour charmer les banquets la jeunesse n'envie
Que le Champagne aux flots resplendissants."

This was, no doubt, before champagne became dry, and extra dry, and brut, harsh, sour, and dosed with cognac brandy; before it assumed that quality which a diplomatist disliked, and of which he believed that others disliked it also, no matter what they professed: he believed that the man who said that he liked dry champagne would say anything. However, the champagne of good years, with its natural sweetness and gentle mousse, is one of the finest inventions of the French genius. A wit said that there were only three human inventions worthy of the ingenuity of man: foil-fencing, the Jesuits, and champagne. However M. de Cazanove cannot conclude his canzonette without a hit at the English:

"Vous, froids Anglais, qui vantez notre France,
Et ses enfants au rire toujours prêts,
Avez-vous soif d'amour, de gaîté, d'espérance?
Buvez, buvez! et vous rirez après!"

We omit the refrain, as the circumstances are no longer

fitting it. But we accept the advice, for we know it to be correct from experience.

> "Et vous verrez les brouillards de votre onde,
> Fuir dans les cieux en nuage vermeil!"

The Italians of our days have also their national pets. Thus Redi, in his poem "Bacco in Toscana," proclaims Montepulciano to be king of all wines!

> "Bella Arianna con bianca mano,
> Versa la Manna di Montepulciano;
> Col mane il tonfano e porgilo a me.
> Questo liquore, che sdrucciola al core,
> O come l'ugola e baciami, e mordemi!
> O come in lacrime gli occhi disciogliemi! ....
> Montepulciano d'ogni vino è il re!"

We hope the Italians will not allow themselves to deviate from the path of progress which they have entered upon, and revert to liqueur wines We have in this Exhibition a number of samples of Italian wines which may go far to counteract the results of former Exhibitions.

The Americans also have a pet wine, which in their opinion beats Champagne, namely Catawba wine. Of this Longfellow sings:

> "Very good in its way.
> Is the Verzenay,
> Or the Sillery soft and creamy;
> But Catawba wine
> Has a taste divine,
> More dulcet, delicious, and dreamy.
>
> "There grows no wine,
> By the haunted Rhine,
> By Danube or Guadalquivir,
> Nor an island or cape,
> That bears such a grape,
> As grows by the beautiful river.
>
> "Drugged is their juice,
> For foreign use,
> When shipped over the reeling Atlantic,
> To rack our brains,
> With the fever pains,
> That have driven the old world frantic."

Here is one for M. de Cazanove, and for the rest of European wine-bards.

However, in my humble opinion, good Catawba is an excellent, marvellously-flavoured beverage. I can enjoy it without thinking all other wines Borgia tinctures or Devil's elixirs.

English literature is rich in allusion to the virtues of wine, and the English people have always been excellent customers of wine-growing lands. Indeed it may be said that the vineyards of Jerez, the Alto Douro, and of Madeira are mainly Britannia's vineyards; while the French vineyards furnish a considerable share of English consumption.

The Germans have perhaps the most varied lyric poetry in praise of wine, probably because their poems are mostly set to music, and are sung by young and old on joyous occasions.

Thus there is the celebrated song,

> "Bekränzt mit Laub den lieben vollen Becher,
> Und trinkt in fröhlich leer!" etc. etc.

The song is full of humour, but a little old-fashioned in cadence and melody. It denounces not indeed foreign wines, but other German Hills, which do not, like those of the Rhine, produce wine, or produce bad wine.

There is the Thuringian three-men wine, so called because, if any one wants to drink it he must be held by a second man, and a third must force it down his throat.

There is Silesian, to which the Devil was treated, but he said that to go on with it was only possible to a born Silesian.

But the end of the *Rheinweinlied* concerns us here, as it expresses the proposition we are here to discuss:

> "So trinkt ihn denn, und lasst uns alle Wege
> Uns freun und fröhlich sein!
> Und wüssten wir wo jemand traurig läge,
> Wir gäben ihm den Wein."

Ay! Wine is a cure for melancholy! and if there were more good wine in the world there would be less melancholy in it.

Among German songs may yet be mentioned:

"Im kühle Keller sitz' ich hier,"

for a bass voice solo.

Lessing's poem of the bibber who cheated Death by telling him he intended to become a doctor and go halves with him as regards his patients, ending in this joyous strophe:

"Ewig soll ich also leben,
Ewig! denn beim Saft der Reben,
Ewig soll mich Lieb und Wein,
Ewig Wein und Lieb erfreun."

Who does not think of Luther's:

"Wer nicht liebt Wein, Weib, Gesang,
Der bleibt ein Narr sein Leben lang?"

and lastly of Göthe's Chorus:

"Sollst uns nicht nach Weine lechzen.
Frisch das volle Glas heran;
Denn das Aechzen und das Krächzen,
Hast du längst schon abgethan."

All factors which promote happiness, promote health. And as wine promotes happiness it promotes health. But it does so on the condition that it be aesthetically used, *i.e.*, in accordance with the dictates of feeling, reason, and science.

MR. A. J. R. TRENDELL moved a vote of thanks to Dr. Thudichum for his able and interesting lecture, which was carried unanimously.

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INDEX TO VOLUME

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INDEX TO VOLUME.

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